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CONTENTS

EDITORIAL

THE NEW CIVILIAN MANAGEMENT (SPECIALISTS) ORGANISATION

Readers of this Journal may have already heard that a new centralised management organisation for Specialist staff in the Ministry of Defenee has now been brought into being. It will deal with Staff Administration Matters for Scientific and certain other Specialists in the Navy Department as well as in the Army and Air Force Departments.

As such, it will cover the work which was previously done by the Superintendent Scientific Personnel (Naval)/Civil Establishments 2 (Naval) and will therefore coneern itself with all staff management questions for Scientifie, Experimental and Assistant grades as well as Draughtsmen and Technieal grades, etc., of the Royal Naval Scientific Service.

Superintendent Scientific Personnel (Naval) and his group have been absorbed into the Civilian Management (Specialist Division) but no attempt will be made in this Editorial to describe in detail how the new Division will be organised to eope with its duties: these will be given in a Defence Council Instruction which, at the time of writing, is in hand for promulgation. It is, however, hoped in a later issue of the Journal to give a much fuller account of its aims and of the advantages it hopes to bring to staff and career management of all affected.

CONTROL CHARACTERISTICS OF DIESEL ENGINES FOR ALTERNATOR DRIVES. Part I

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Introduction. The comparatively recent development of high performance electronic governors[1] and thyristor bridge automatic voltage regulators [2, 3] for diesel-alternator power generation systems, at Admiralty Engineering Laboratory, West Drayton, has initiated a detailed study of the control characteristics of the coupled systems. In the light of previous experience in the Admiralty with diesel-alternator systems it is clearly necessary to have a good understanding of the coupling between the two systems so that the most can be made out of these latest developments.

Initially the study has been confined to a single generator power system for which a basic block diagram is shown in Fig. 1. The system is a classic two input-two output system for voltage magnitude and frequency. The system is separated into its basic electrical and mechanical subsystems with the associated coupling signal paths as shown. The interaction between rotational speed, generated e.m.f. and electrical torque is fundamental and common to all systems.

It is evident that conventional design of the governor system as an isolated subsystem is an oversimplification. As shown in Fig. 2 the electrical subsystem interacts in the mechanical system as torque feedback, dependent upon the characteristics of generator and a.v.r. The characteristics of alternator control are usually based on the generalised theory of electrical machines and have been extensively studied. The control characteristics of diesel engines are less well known and, partly owing to the pulse-like nature of the power stroke, less amenable to analysis. Until recently these characteristics were not so important because of the poor performances of the control systems involved; however they may represent a major limitation to performance in the future. A study of these characteristics form the major part of these two articles.

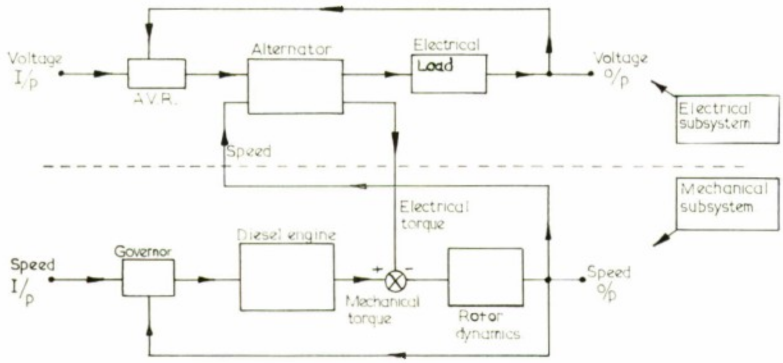


FIG. 1. Block diagram of a Single Diesel-Alternator Set.

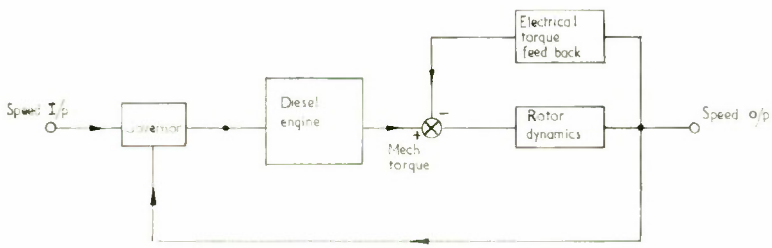


FIG. 2. Block diagram showing Electrical Torque Feedback on the Engine.

Pulse Properties of the Diesel Engine Subsystem

The dynamics of the diesel engine speed control loop are concerned primarily with the inertia equation

$$J\dot{\omega}+F(\omega)=T_m-T_e$$

where J is the equivalent shaft inertia of the engine and rotor, $F(\omega)$ is a drag torque; and T_m and T_e are the mechanical and electrical torque respectively.

The mechanical torque is produced in a sequence of pulses from the cyclic firing of the engine cylinders. The size of the torque-pulses is defined by the amount of air and fuel in each cylinder at firing, and by controlling the amount of fuel injected into each cylinder, the size of the torque-pulse is varied. The properties of this control are analogous to those of a sampled-data control system.

Similarly the characteristics of the electrical subsystem will have analogies with sampled-data control schemes if the excitation scheme uses thyristor-bridge control units[2]. The mechanical subsystem will therefore be of one of the two types, continuous torque load or pulse torque load. In the conventional case where the a.v.r. is a continuous controller the diesel-engine speed control loop may be very sensitive to resonances produced by the electrical torque feedback. In effect the amplitude modulation characteristics of sampling can produce apparent low frequency resonances by interaction between comparatively high frequency resonances and the sampling frequency. This characteristic is an additional cause of trouble experienced with conventional flyball governing systems.

In the case of thyristor-bridge a.v.r.'s the interaction will depend upon the ratio of sampling-times between the two loops. As the system sampling frequencies are geared to the rotational frequency of a set, it is possible to relate the ratio to the number of engine cylinders and exciter poles *etc.* For the engine the sampling time T_d is given by

$$T_d=\frac{120}{n.N}$$

for a 4 stroke engine, with n cylinders, at N r.p.m.; and for the alternator the sampling time T_a is given by

$$T_a=\frac{60}{mp_eN}$$

where m is the number of controlling phases; p_e the number of exciter pole pairs.

Hence

$$\frac{T_a}{T_d} = \frac{n}{2mp_e}$$

A plot of this ratio for $P_e=2$ is shown in Fig. 3 for various numbers of engine cylinders and thyristor bridge phases. In the cases where $4<T_a/T_d>0{\cdot}25$ the sampled-data action is significant. This covers the entire range of Admiralty diesel-alternator sets.

Thus the principal points to be borne in mind are,

(i) In high performance systems the effects of alternator and a.v.r. design on the design of the governor subsystem should be understood.

(ii) The latest improved actuators and control systems for diesel-governing may have interactions with conventional a.v.r's. that have not been previously predicted owing to sampled-data action.

(iii) The latest types of a.v.r. may produce more complex forms of interaction due to the presence of two discrete control systems.

(iv) To enable the system study to proceed a detailed study of the sampled-data properties of a diesel engine is required.

Sampled Data Model of a Diesel Engine

General

The application of control theory to diesel engine governing was pioneered by Welbourn *et al.*[4] Analyses since then have regarded the engine as a device which converts the fuel-control signal to an output-torque signal through a transport delay equal to the time between individual cylinder firings. This implies a continuous injection of fuel producing a corresponding output-torque at a given time later, and obviously does not conform to the true operation. A better model is obtained by reverting to first principles.

The torque produced by any one cylinder has a fixed duration equal to the length of the power stroke, and a magnitude determined by the peak pressure reached in the cylinder during combustion. It seems natural therefore to model this output using pulses. The size of the pressure peak is dependent upon both the amount of air and the amount of fuel injected in the cylinder during burning. In turbocharged engines the air forced into the cylinder depends upon energy carried by the engine exhaust pulses to the turbine. This turbocharging represents an additional feedback mechanism around the engine which has previously been ignored.

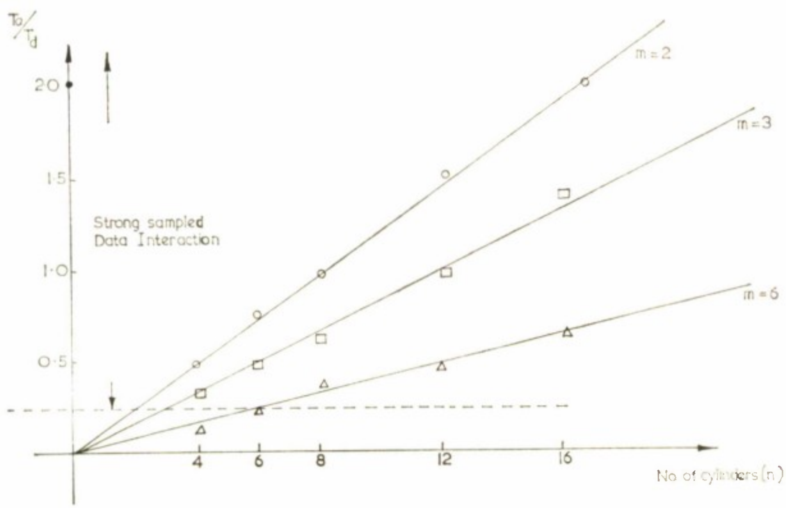


FIG. 3. Variation in Sampling-Time Ratio with Engine and Exciter Types (pe=2).

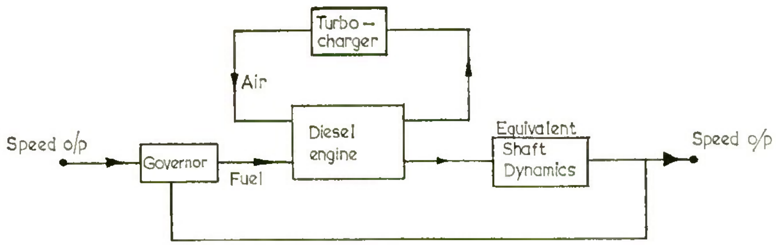


FIG. 4. Block diagram of Turbocharged Diesel.

The amount of fuel injected into the engine is independently controlled by the governor system and is the manipulated quantity in speed control. The characteristics of the fuel injectors and how they respond to control information is therefore important. The next three chapters of this article are devoted to a detailed discussion of the basic turbocharged engine block diagram depicted in Fig. 4 with regard to

(i) Torque pulse production for multi cylinder engines.

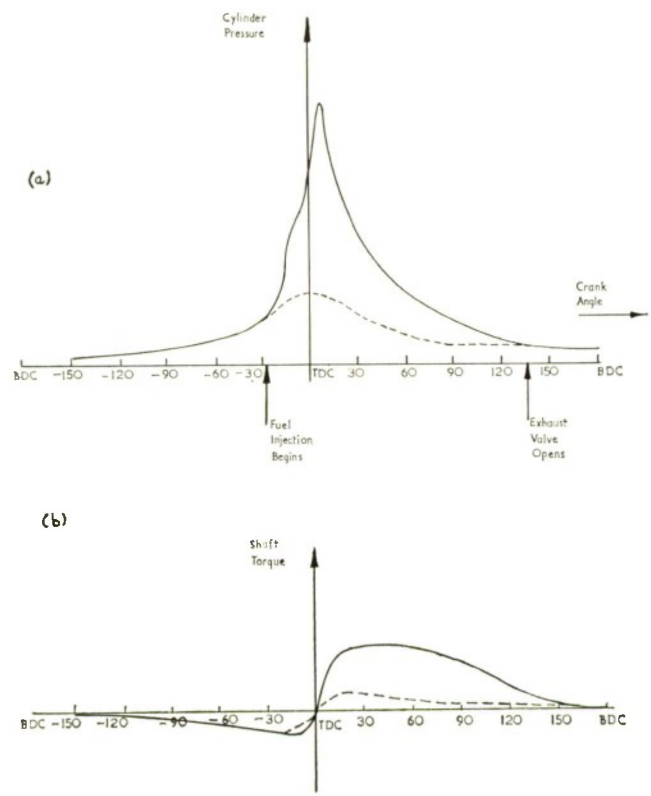
(ii) Turbocharger influence.

(iii) Injector characteristics.

The Conversion of Fuel Rack Movement to Torque Pulse Output

The torque-production process is obviously of a discrete nature and it is logical to base the modelling of the engine on sampled-data concepts. Four-stroke engines only will be considered but the approach can obviously be applied to the two-stroke variety.

A typical gas pressure diagram for one cylinder is shown in Fig. 5(a). It should be noted that the fuel injection begins some time before top-dead-centre (t.d.c.), and the combustion takes place in such a fashion that the peak pressure is reached some time after t.d.c. The action of the crank and connecting-rod mechanism is to convert this cylinder pressure into torque, Fig. 5(b), by a modulating process. The mechanism of fuel-control during the injection period is vitally important as it determines how the control information is utilised. A speed control system is shown in Fig. 6 where the speed measurement and the fuel-rack movement are continuous, the injection however contains a sampling mechanism which, in the first analysis, will be regarded as a pure sampling action.



FIGS. 5 (a). Typical Gas Pressure Diagram.

(b) Resulting Torque Diagram.

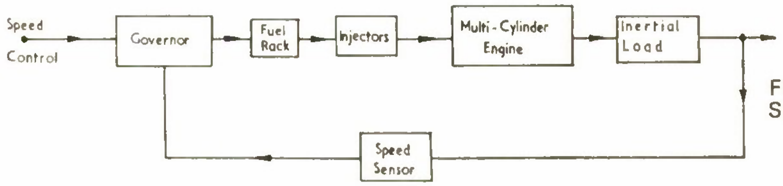


FIG. 6. Conventional Governor Speed Control Loop.

Fig. 7 shows a typical injection-pump mechanism which is driven *via* a camshaft and is therefore synchronised to the engine speed. As the pump piston moves upwards past the fuel-inlet ports the body of the fuel between the pump-piston and the injector is trapped and rapidly pressurised so that fuel is injected into the combustion chamber. The injection proceeds until the helical groove machined in the pump-piston allows fuel overspill to occur. Since the injection must necessarily begin at the same instant during each cycle the amount of fuel injected is determined by the instant the helix allows overspill; the position of the fuel rack being sensed at that instant thereby sampling the control signal (a more detailed analysis follows later). The engine then produces a torque-pulse from the fuel sample. A block diagram showing the equivalence between the speed-governing loop and a sampled-data system is shown in Fig. 8.

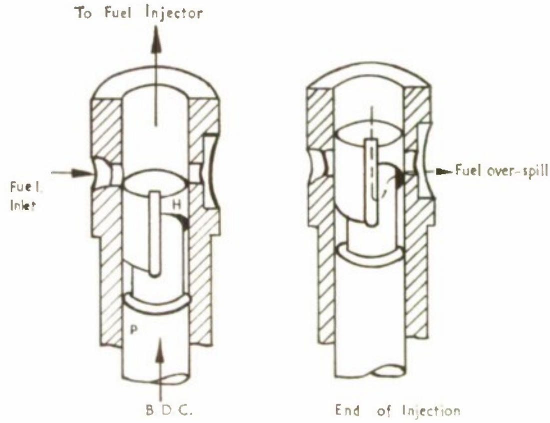


FIG. 7. Typical Fuel Injector Pump Mechanism.

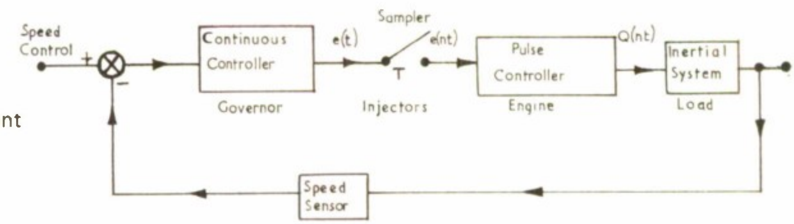


FIG. 8. Corporative Diagram of Speed Control Loop and equivalent Sampled-Data Control System.

Four, Six and Eight-cylinder Engine Models

For constant-speed generator systems the time between individual injections is constant and hence the system has a consequent sample-period of

$$T = \frac{120}{n\,N}$$

Fig. 9 shows the individual torque outputs of a four-cylinder engine and how they combined together to give the developed shaft-torque. The corresponding sampled-control signals are also illustrated. Fig. 10 shows the relationship between the input signal and the output signal of a sampling system incorporating a zero-order hold (z.o.h.).

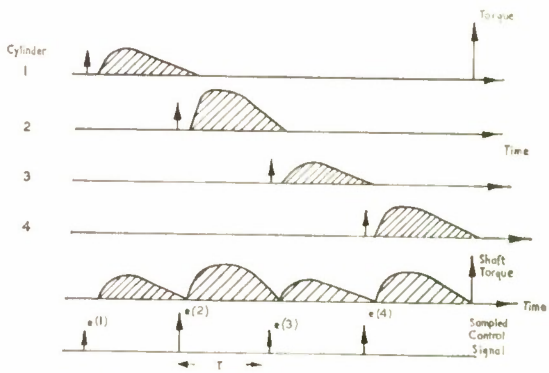


FIG. 9. Cylinder and Shaft Torque Diagrams for a Four Cylinder Engine with respective Sampling Instants.

The input and output waveforms of these two systems show certain similarities. This becomes even more evident when they feed low-pass systems where higher harmonics are severely attenuated. Adopting the obvious procedure of equating the torque-pulse to a square-pulse having the same area, *i.e.* equal-energy content, then the idealised model of a four-cylinder engine becomes equivalent to a sampler and z.o.h. circuit.

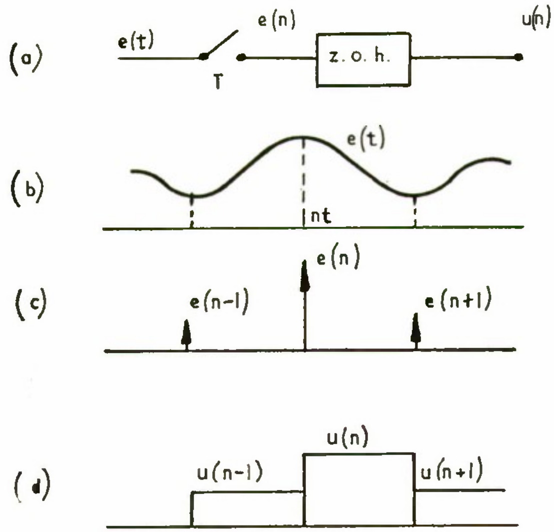


FIG. 10. Diagrams for Sampler and Zero-Order Hold Circuit (a) Block Diagram, (b) Input Waveform, (c) Sampled Input Waveform, (d) output waveform.

The six-cylinder engine has rather different characteristics since there are periods during the cycle when two cylinders are producing power simultaneously, *i.e.* there is an overlap of torque from any given sample into the following sample period (Fig. 11). To idealise the situation an unusual form of hold circuit called a *partial-first-order hold* shown in Fig. 12 is proposed. Something like 23% of the total pulse energy overlaps into the second sample period corresponding to values of α and β of 0·5.

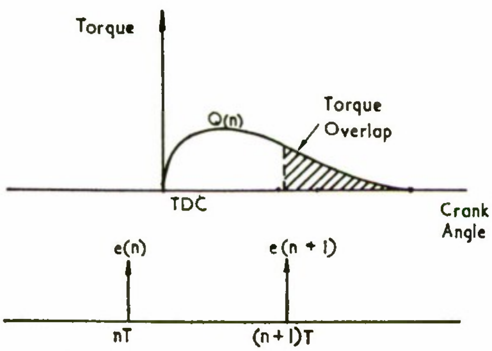


FIG. 11. Torque Output Pulse and Respective Sampling Instants for Six-Cylinder Engines.

The eight-cylinder engine extends the torque-overlap for the whole duration of the second sample, Fig. 13. The amount of energy present from the torque-overlap is in the region of 50%. The corresponding model chosen is shown in Fig. 14.

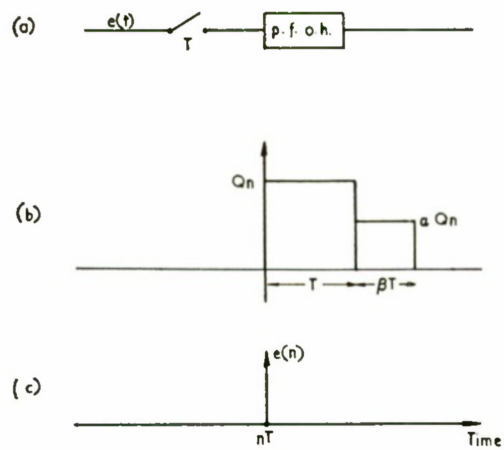


FIG. 12. Diagrams for Partial First-Order Hold Model (a) Block Diagram, (b) Output Waveform (impulse Response), (c) Input Impulse.

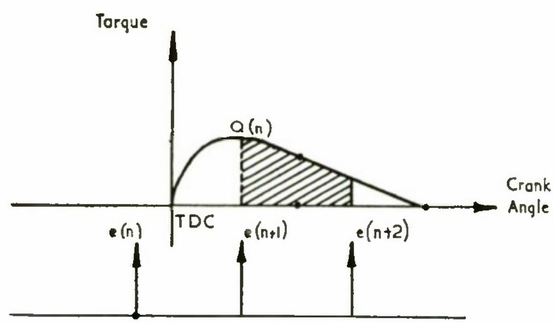


FIG. 13. Torque Output Pulse and Respective Sampling Instants for Eight-Cylinder Engines.

The transfer function for the various holds considered can be written

$$M(s)=\left[\frac{1-e^{-sT}}{s}+\frac{\alpha(1-e^{-s\beta T})}{s}\,e^{-sT}\right]Q(n)$$

where Q(n) is the heights of the main pulse and

(1) 4-cylinder engine $\alpha=0$, $\beta=0$

(2) 6-cylinder engine $\alpha=0{\cdot}5$, $\beta=0{\cdot}5$

(3) 8-cylinder engine $\alpha=1{\cdot}0$, $\beta=1{\cdot}0$

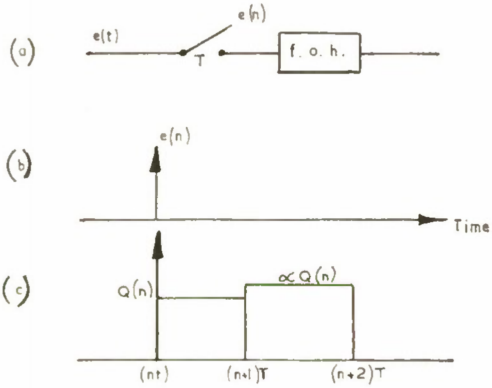


FIG. 14. Diagrams for First-Order Hold.
(a) Block Diagram, (b) Input Pulse,
(c) Output Pulse (Impulse Response).

The Effect of Pulse Action on the turbocharger loop.

A block diagram of the turbocharger loop and engine is shown in Fig. 15. The driving power to the turbine is supplied from the exhaust gas pulses of the i.c. engine in much the same way as the torque pulses drive the engine load. The turbine drives the compressor which forces air under pressure into the inlet manifold. On the opening of an inlet valve, air then flows into the corresponding cylinder with a flow rate depending on dynamic conditions in the turbine and inlet manifold, *etc.* Inflow ceases on closure of the inlet valve and a sample of air is effectively defined at this instant. This sample is then compressed and the power stroke follows. The particular pressure pulse from this process is however not released to the turbine until the end of this power stroke.

The turbocharger loop therefore contains two pure delays each equal to the length of the power stroke. The formation of the mass of air sample is an unusual process since unlike pure sampling it depends on the length of time the air sample is exposed to changes in the inlet flow rate. Hence in a sampled data model the sampling process must be given an equivalent circuit component.

The conversion of exhaust pulse energy to inlet manifold pressure is *via* a high order continuous system differential equation with variable coefficients. Ideally to avoid surge conditions the constants are designed so that the system consists of the effective series lags of turbo compressor and manifold, with the inertia of the compressor acting as an integrator of the pressure pulses from the engine.

The effect of this loop on the engine performance will depend on the cross coupling between fuel and air, and output torque and exhaust pressure. For highly supercharged engines the coupling is undoubtedly quite significant and, as far as the authors are aware, has never before been studied from the control point of view. Preliminary work in this area has started at the University of Sussex.

Sampling Characteristics of the Injector-Pump Mechanism

Recent results from frequency response testing of a normally aspirated engine[5] have indicated that the injector pump has appreciable dynamic characteristics in addition to those of a pure sampling process. This is primarily due to rotational movement of the helix during the injection of fuel, which results in the fuel mass injected being sensitive to rate of change of rack movement.

If the fuel rack is perturbed sinusoidally then this motion will be translated to fuel-pump-piston rotation. With the engine giving a certain amount of steady power, the vertical distance between piston surface and helical groove at spill-off will be given by

$$y=y_d+A\sin(\omega t+\phi)$$

Assuming that during fuel injection the piston is driven by a constant velocity cam, then y is also defined by

$$y=V_c\, t$$

A simultaneous solution of these two equations for the duration of injection t_i is given by

$$t_i \sim \frac{[y_d + A\sin\phi]}{[v_c - A\omega\cos\phi]}$$

and, assuming a constant rate of injection, the mass of fuel m_k is given by

$$m_k=K_m\,\frac{(y_d + A\sin\phi)}{(V_e - A\omega\cos\phi)}$$

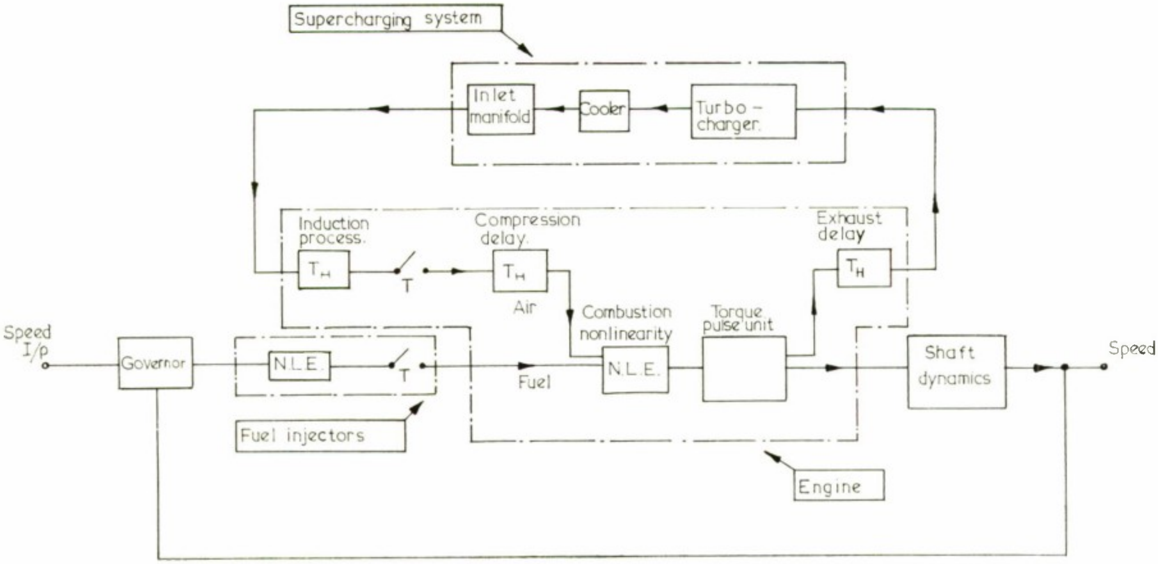


FIG. 15. Block Diagram of Complete Engine.

Now if the injector was an ideal sampler the mass injected would be

$$m_k = \frac{K_m}{V_c}\,[y_d + A \sin \phi]$$

Hence the injected mass can be greater than this for certain ranges of ϕ. The term in the denominator is the rate of change of the vertical helix movement due to rate of change of fuel rack position and for large input signals it results in a nonlinear dynamic control. For small signal perturbations the injector can be approximated to a pure sampler with derivative control. The derivative time constant is directly proportional to the steady-state output and thus the control properties of the injector vary with load.

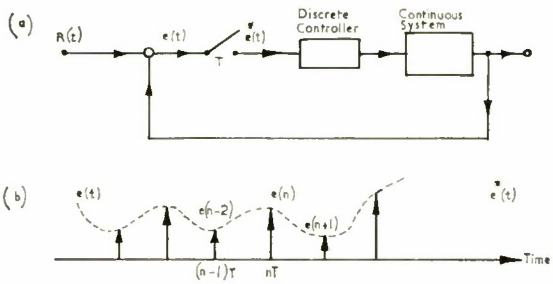


FIG. 16. Diagrams for Generalised Sample-Data Control Loop (a) Block Diagram,
(b) Continuous and Sampled Waveforms.

Stability Analysis of Discrete Control Systems

The analysis of sampled data systems can be made in either the frequency domain or the time domain as in the case of continuous systems. The frequency domain approach, however, has many pitfalls making it a less attractive tool than it is in continuous system theory. An explanation of the theory involved is given below and the time domain approach is reserved for the second article.

Harmonic Analysis of the Sampling Process

The sampler is a mechanism which modulates the input signal to a system by a periodic impulse train as shown in Fig. 16. In terms of a Fourier series the impulse train can be expressed as

$$I(t) = \frac{1}{T}\left[1 + 2\sum_{n=1}^{\infty} \cos(n\omega_s t)\right]$$

Suppose the system input is a sinewave

$$x(t) = A \sin(\omega t + \phi)$$

Thus the modulator output will be

$$x(t)\ I(t) = \frac{A}{T}\sum_{n=-\infty}^{+\infty} \sin\Big((n\omega_s + \omega)t + \phi\Big)$$

This expressed the signal in terms of the upper- and lower-sidebands of the sampler harmonics. If this signal is passed into an engine with Laplace transformation

$$M(s)\ G(s)$$

then the output signal is given by

$$y(t) = \frac{A}{T} \sum_{n=-\infty}^{+\infty} M(j\omega + jn\omega_s)\ G(j\omega + jn\omega_s)\ \sin\left((n\omega_s + \omega)t + \phi\right)$$

On feeding back this signal to the sampler frequencies

$$(n\omega_s + \omega)$$

will appear as frequencies ω due to the modulating process. Hence the feedback signal will appear to contain a sine wave of the following type

$$\frac{A}{T} \sum_{n=-\infty}^{+\infty} M(j\omega + jn\omega_s)\ G(j\omega + jn\omega_s)\ \sin(\omega t + \phi)$$

The stability criterion therefore reduces to

$$\sum_{n=-\infty}^{+\infty} \frac{M(j\omega + jn\omega_s)}{T} G(j\omega + jn\omega_s) = -1$$

In text books[6], the quantity on the LHS is denoted $G^*(j\omega)$ and the equivalent Nyquist criterion is written

$$G^*(j\omega) = -1$$

The deviation of this criterion from the conventional

$$G(j\omega) = -1 \qquad \ldots (1)$$

is clearly of interest.

For low-pass systems where $G(j\omega) \gg G(j(\omega_s - \omega))$ *etc.* for higher sidebands the criterion reduces to

$$\frac{M(j\omega)}{T} \cdot G(j\omega) = -1 \qquad \ldots (2)$$

This clearly represents a simple modification of equation (1). However if the time constants are in the region of the sampling time and $G(j\omega) \sim G(j(\omega_s - \omega))$, as $\omega \to \omega_s/2$ then $G^*(j\omega)$ is approximated by

$$\operatorname{Im}\left[M\left(\frac{j\omega_s}{2}\right) G\left(\frac{j\omega_s}{2}\right)\right] = -\frac{T}{2}$$

and if resonance occurs above $\omega_s/2$ then this will drastically affect the expression for $G^*(j\omega)$. It should be noted that if $M(j\omega)G(j\omega)$ is known

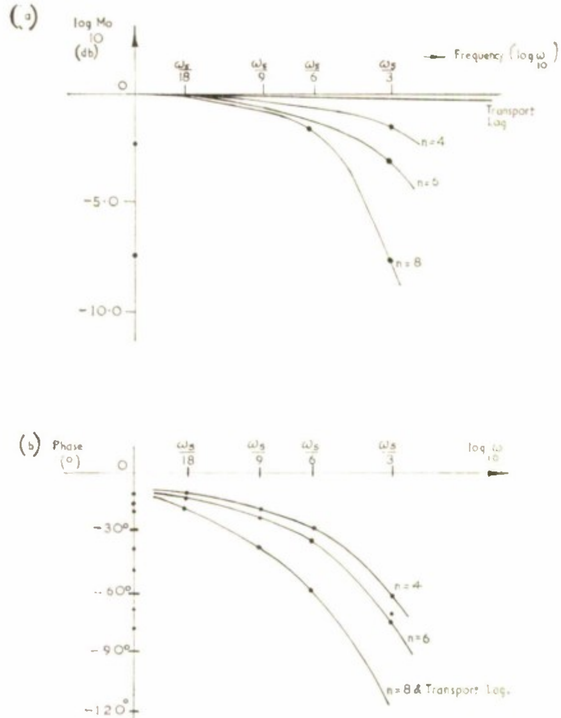


FIG. 17. Bode Plots for the discrete action of Four, Six and Eight Cylinder Engines compared with the Transport Lag Model.
(a) Magnitude Plot, (b) Phase Plot.

for all frequencies then $G^*(j\omega)$ can be constructed graphically from the equation

$$G^*(j\omega) = \sum_{n=\infty}^{+\infty} \frac{M(j\omega + jn\omega_s)\ G(j\omega + jn\omega_s)}{T}$$

The relevance of the sampler in the system therefore depends to a great extent on the frequency domain characteristics of the continuous part of the system. In order to compare the engine models derived in the chapter entitled, " Sampled-data Model of a Diesel Engine ", with conventional models, it is therefore necessary to restrict the analysis to those represented by Equation (2).

$G^*(j\omega)$ for low-pass systems.

Now the engine Fourier transform is given by

$$M(j\omega) = \left[\frac{(1 - e^{-j\omega T})}{j\omega} + \alpha \frac{(1 - e^{-j\omega\beta T})^{-j\omega T}}{j\omega}\right]$$

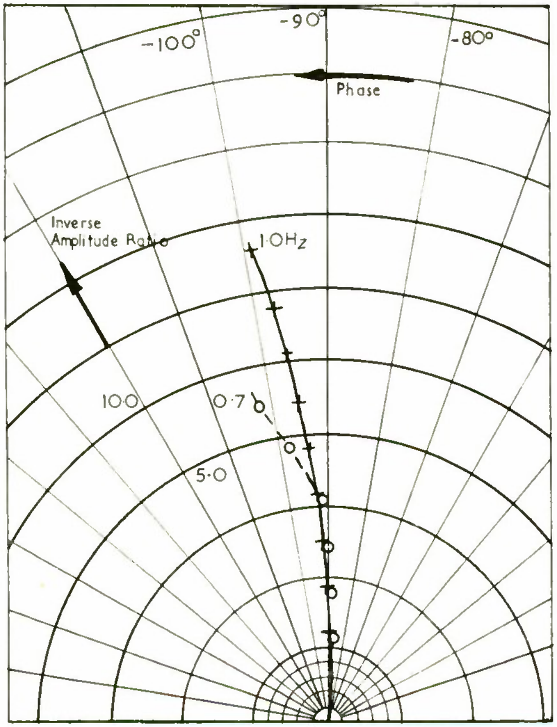


FIG. 18. Inverse Nyquist Plot for a Six-cylinder Diesel Engine with Transfer Function M (jω) G(jω).
Theoretical curve ++++
Experimental curve oooo.
Points plotted at 0·1 Hz intervals.

hence for systems with low-pass characteristics

$$G^*(j\omega) = \left[e^{-j\omega T/2} + \alpha\beta\, e^{-j\omega T(1+\beta/2)} \right] G(j\omega)$$

which gives

$$n=4 \quad G^*(j\omega) = e^{\frac{-j\omega T}{2}} G(j\omega)$$

$$n=6 \quad G^*(j\omega) =$$

$$\left[e^{\frac{-j\omega T}{2}} + 0{\cdot}25\ e^{-j\omega T\,1{\cdot}25} \right] G(j\omega)$$

$$n=8 \quad G^*(j\omega) = e_{-j\omega T}\, G(j\omega)$$

In comparison, the previous criteria of a simple transport lag is

$$e_{-j\omega T} G(j\omega) = -1$$

Comparing the various engines against this model it appears that this formula is only true for an eight-cylinder engine. Over the frequency range usually investigated, the engines can be approximated by

$$n=4 \quad \frac{M(j\omega)}{T} = \frac{1}{(1+j0{\cdot}5\omega T)}$$

$$n=6 \quad \frac{M(j\omega)}{T} = \frac{1}{(1+j0{\cdot}65\omega T)}$$

$$n=8 \quad \frac{M(j\omega)}{T} = \frac{1}{(1+j\omega T)}$$

The conventional model therefore gives a pessimistic assessment of phase shift introduced into the control loop by four- and six-cylinder engines, and will give an optimistic assessment for more than eight-cylinder engines.

In Fig. 17 the gain and phase plots for normalised N (jω) are shown. The transport lag is clearly unrepresentative of all engines above $\omega_s/6$.

Example 1. The conventional model of a six-cylinder engine was frequency response tested by Welbourn[4]. An inverse Nyquist plot is shown in Fig. 18. The inertial load had a transfer function

$$G(j\omega) = \frac{K_D}{(1+j21{\cdot}1\omega)}$$

The engine speed was 500 r.p.m. and hence the sampling frequency was 25 Hz. From the Bode plots it is clear that the model

$$M(j\omega) = \frac{1}{(1+j0{\cdot}026\omega)}$$

is adequate up to 2 Hz. A plot of M(jω) G(jω) gives a better fit as shown in Fig. 18. However for high performance governor systems the frequency range of interest is above 2 Hz and verification of the system pulse transfer function at frequencies higher than this presents certain problems; such as resonant vibration of the engine mountings; and measurement difficulties with sideband frequencies present.

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FIBRE REINFORCED PLASTICS

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Introduction

The decision by the Navy Department to place a contract for the construction of a minesweeper hull in glass reinforced polyester resin is one of many recent examples of the increasing use of reinforced plastics in primary structural applications, and is indicative of the growing confidence of the designer in making use of the unique properties of these materials. In this article an attempt is made to review the properties, advantages and disadvantages of fibre reinforced plastics as they appear at present and to suggest areas in which there might be further development.

Available Materials

Table I summarises the properties of the most commonly used fibrous reinforcing materials. A wide variation in properties is evident, even amongst fibres of the same material and this variation may arise either by accident or design. The range of glass fibre strengths, for instance, is due to the effects of mechanical damage caused during processing and any handling before lamination while the properties of carbon fibres can be varied by careful control of the process to give different combinations of strength and stiffness.

TABLE I.
Reinforcement Properties

	Specific Gravity	*Tensile Strength MN/m²*	*Tensile Modulus GN/m²*
Glass	2·55	1800 - 3500	70
Carbon	1·9	1800 - 3000	200 - 400
Steel	7·8	2700 - 3100	210
Asbestos	3·2	3200	190
Boron	2·3	3500	400

The bulk of the reinforcement currently used is glass in various forms—woven fabrics, chopped fibre mat or as rovings for filament winding—and while efforts are being made to provide carbon fibres in similar forms, glass has a great advantage economicaly, being of the order of 10/- per kilogram compared with carbon fibres which are two or three orders of magnitude higher. Steel wires are also comparatively cheap but suffer from the disadvantage of high density.

As glass fibres form the major part of the reinforcement, so polyester resins constitute the bulk of the matrix material, again due largely to cost and convenience. Typical costs are 5/- per kilogram for polyester resins and 10/- per kilogram upwards for epoxide resins. For specific applications, the special properties of the more expensive resins may merit consideration and, particularly with epoxide resins, there is scope for tailoring the matrix to have carefully defined properties such as modulus, elongation at failure and heat distortion temperature. Table II shows some of the properties of polyester and epoxide resins and again a wide variation can be seen depending upon formulation and processing.

TABLE II.
Resin Properties

	Polyester	*Epoxide*
Specific Gravity	1·11 - 1·45	1·11 - 1·40
Tensile Strength MN/m^2	40 - 90	30 - 90
Tensile Modulus GN/m^2	2 - 4	1 - 4
Compressive Strength MN/m^2	90 - 250	100 - 200
Shrinkage %	4 - 8	1 - 4
Heat Distortion Temperature °C	60 - 200	40 - 300

When the reinforcement and matrix materials are put together to form a composite, the final properties are influenced by the distribution of the reinforcement as well as by the properties of the component materials. Table III shows typical values for a range of glass and carbon reinforced plastics and the high strengths which may be achieved are

TABLE III.
Composite Properties

	Fibre Content %	*SG*	*Tensile Strength MN/m^2*	*Tensile Modulus GN/m^2*	*Comp. Strength MN/m^2*
Unidirectional Glass Epoxide	60 - 90	1·7 - 2·2	550 - 1750	30 - 65	300 - 500
Satin Weave Glass Polyester	50 - 70	1·6 - 1·9	250 - 400	15 - 25	200 - 300
Glass Woven Roving Polyester	45 - 60	1·5 - 1·8	230 - 350	13 - 17	100 - 150
Glass Random Mat Polyester	25 - 40	1·4 - 1·5	60 - 150	6 - 12	100 - 150
Glass Filled Moulding Compound	5 - 25	1·8 - 2·0	35 - 70	10 - 14	140 - 180
Unidireetional Carbon Epoxide	50 - 70	1·5 - 1·6	1000 - 1750	150 - 300	
Bidireetional Carbon Epoxide	50 - 70	1·5 - 1·6	500 - 900	75 - 150	

immediately evident. This combined with the low density of reinforced plastics is one of the most attractive features of these materials. The total cost is also influenced by the way in which the reinforcement is used and while the better quality composites make more economical use of materials the processing costs will probably be higher.

Advantages and Disadvantages of Reinforced Plastics

One of the major advantages of fibre reinforced plastics has already been mentioned—the high specific strengths which can be achieved with careful use of the material. The very high strengths are, however, only obtained at the expense of considerable anisotropy and Fig. 1 shows the strength properties in various directions for three types of glass reinforced plastic. It follows that the most efficient use of these materials is likely to be in applications where there is a well-defined uniaxial load to be carried. It is possible, in theory, to vary the properties of composites locally to satisfy design requirements but in practice this is difficult and expensive.

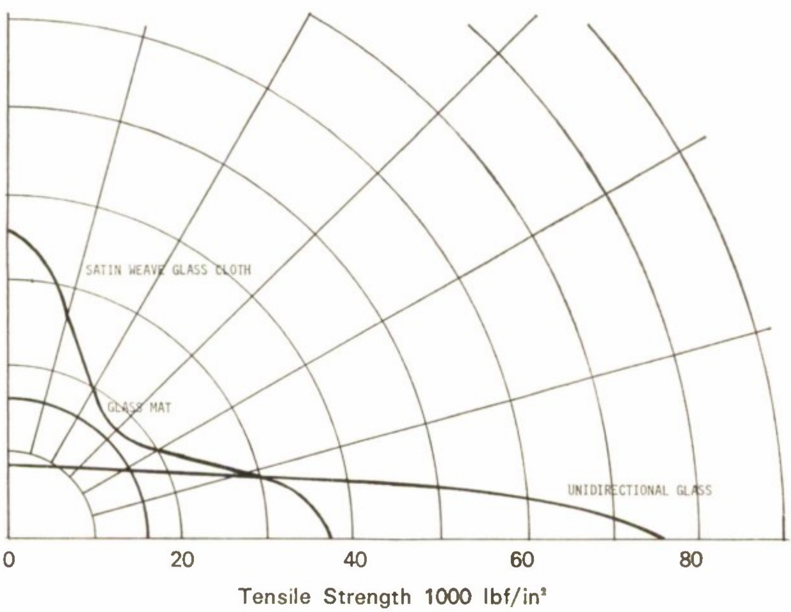

FIG. 1. Anisotropy of Composite Materials.

Complex shapes are easily reproduced with quite simple moulding techniques and a highly skilled labour force is not required for fabricating except for the highest quality composites. Most operations are, however, labour intensive and for large items such as ship structures labour costs form a large proportion of the total. For small scale production such as would be contemplated with relatively large composite vessels the amortisation of mould costs also adds significantly to the overall costs.

For naval uses, there are other advantages in the use of glass reinforced plastics since they are non-magnetic, non-conducting and radar and acoustically transparent. This is not necessarily true of other fibrous composites—carbon fibre composites, for instance, will conduct electricity particularly along the fibre length although the resistance is quite high. Finally, and of great importance in a marine environment, reinforced plastics are non-corrodable and very resistant to biological attack. These last two advantages raise the possibility of structures with greatly reduced maintenance costs which can be used to offset the generally higher first cost of items made in reinforced plastics.

While reinforced plastics do not suffer from corrosion in the sense that this term is applied to metallic materials, glass reinforced plastics in particular are greatly affected by the presence of water and the various matrix materials all readily absorb it. This water, and any which travels along any detached fibres, tends to degrade the composite, with a lowering of strength properties and frequently a small drop

in modulus. Fig. 2 shows typical degradation curves for the flexural and tensile strengths of a glass woven roving-polyester composite immersed in water. The time scale only relates to a particular set of immersion conditions, in this case water at 1000 p.s.i. pressure and ambient temperature, and can be varied by changing the water pressure and temperature and the degree of protection, such as painting, given to the composite. Ultimately, a loss in strength of some 20 - 25% can be expected with the materials currently available. Glass fibres are chemically treated to promote adhesion to the resin and to restrict the loss of strength in contact with water and careful choice of resin and reinforcement are still needed to limit the strength loss to 20%. In the past, strength losses of 50 - 60% were met. Present indications are that water degradation of carbon fibre reinforced plastics is a very minor problem.

impetus behind work on both boron and carbon fibres and with these reinforcements it is possible to construct composites with stiffness at least as good as the common metallic materials. Both of these high modulus fibrous reinforcements are very expensive and even with the projected cost reductions, as increased production becomes available, it is inconceivable that ship structures would be built wholly of carbon or boron fibre composites. There does, however, appear to be some merit in using carbon fibre as a local stiffening for a glass laminate. The choice then is of how to use the carbon, whether as a separate framework or as a more intimate mixture of glass and carbon. Strength of materials theory would indicate that this latter approach would lead to the carbon carrying a disproportionate share of the load. It seems possible, however, that a few per cent of carbon fibres could give a large boost to the com-

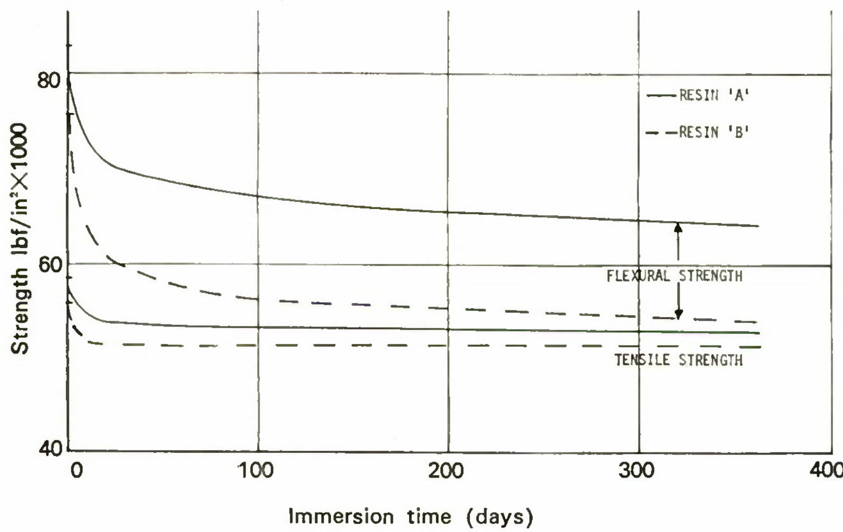

FIG. 2. Loss of Strength of Roving Laminates.

A major shortcoming of the glass reinforced plastics is their low stiffness, which is evident from the data in Table III. This leads to the design of structures on their ability to resist excessive distortion and buckling rather than on their ability to carry stress and can pose severe problems with the mounting of large items of machinery where the machine may be stiffer than the surrounding structure. The low stiffness of glass reinforced plastics was the

posite stiffness (100%) with virtually no increase in labour cost although there would obviously be an increased material cost. Due to the low strain to failure of the high modulus carbon fibre a lower safety factor must be accepted on the carbon although not on the overall performance of the composite. The use of mixed fibre composites will obviously make the design of composites more complicated and increase problems of anisotropy.

In addition to their low modulus, glass reinforced plastics also suffer permanent damage at comparatively low tensile stress levels. The onset of this damage is frequently shown by a slight change in the slope of the stress strain curve at perhaps $\frac{1}{4}$ or $\frac{1}{3}$ of the ultimate tensile strength and the damage itself appears first as a failure in the bond between the matrix and fibres lying at right angles to the load. At higher stresses this debonding acts as a crack initiator and causes crazing in the surrounding matrix. In a cross-plied laminate the original debonding damage is often deflected at the interface between adjacent plies and produces delamination which can be of great trouble if subsequently it is necessary to carry a compressive load. Fig. 3 shows both debonding and delamination damage in a cross-plied glass-epoxy composite subjected to tensile load.

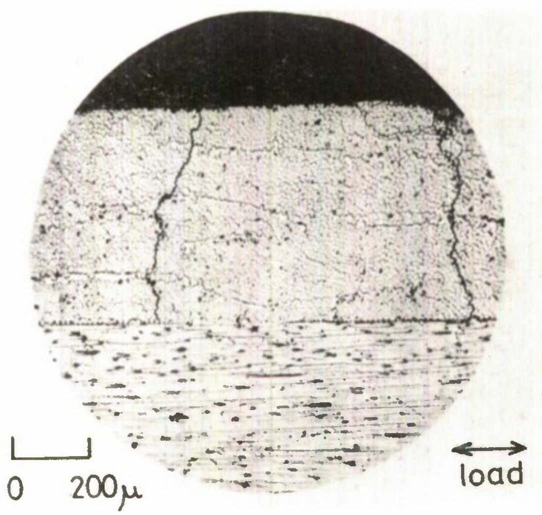

FIG. 3. Debonding and Delamination in Glass Reinforced Plastics.

The onset of debonding, which occurs as a result of a strain concentration caused by the disparity of properties of the fibres and matrix, might be controlled by the use of a resin with a sufficiently high elongation to accomodate the large strains produced. Unfortunately, such a resin is likely to have inferior properties in other respects such as modulus. The difference in mechanical properties of the fibres and matrix can also cause debonding under other load conditions notably compressive loading where there is a tendancy for the matrix to split away from the longitudinal fibres resisting the load.

The purpose of the so-called plastics factor or more simply the large safety factors commonly used with a reinforced plastic structure is to enable the working stress range to be placed below the stress at which significant debonding takes place. The problem is likely to be much reduced with carbon fibre reinforced plastics due to the much lower overall strain levels which will be found together with the fact that these fibres are anisotropic in themselves being less stiff across a diameter than along the length.

A major limitation of all reinforced plastics is that of temperature since the resins undergo a transition at some temperature in the range 50°C - 300°C depending upon the formulation and cure schedule used. Beyond this temperature, load carrying capacity falls very sharply and under a fixed stress, deflections increase rapidly as shown in Fig. 4. Typically for the low temperature curing resins used in ship and boat building this transition will occur at 50° - 60°C. Long periods in this temperature range have the effect of raising the transition by perhaps 20° - 30°C but the interrelation between time temperature and resultant properties is not fully understood. Resins with good high temperature properties are usually of greater interest to the aircraft industry which has been the major outlet and the cost is normally quite high.

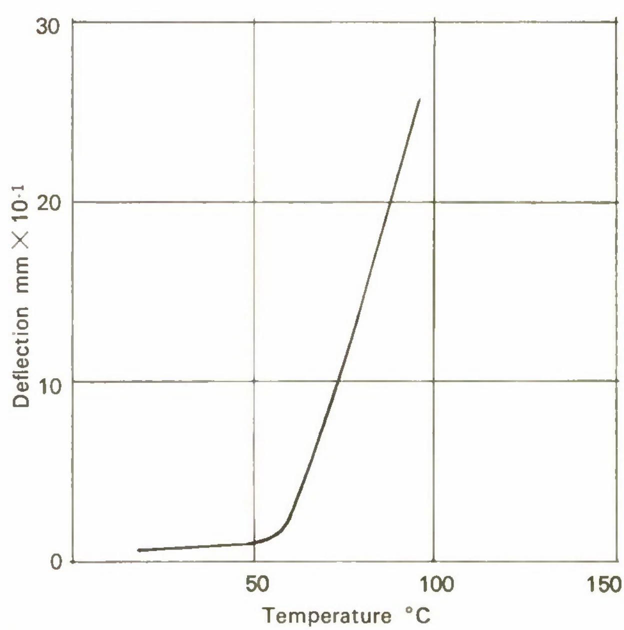

FIG. 4. Effect of Temperature on Laminate

Future Developments

The major problems arising in reinforced plastics have been outlined and over the next few years improvements will undoubtedly take place to solve these problems.

Development can be divided roughly into three areas:

(i) Materials.
(ii) Design.
(iii) Production.

There has been for many years a steady effort by both the resin and glass manufacturers to reduce the deleterious effects of water and this can be expected to continue. At the moment 80% strength retention is regarded as the best that can be achieved, although a few years ago such a figure would have been regarded as extremely optimistic. Carbon fibres are obviously going to find increasing use especially as the cost can be expected to be reduced substantially. In the resin field there is now interest being shown in the behaviour of the resin within the composite, which, hopefully, will indicate in more detail the optimum requirements for a laminating resin.

A major step forward is likely to occur in the design field where it is becoming increasingly apparent that there is insufficient knowledge and experience available to produce efficient reinforced plastic structures for any but the simplest applications. The trend towards computerisation of design calculations is increasing in many areas and there are additional advantages of this approach with reinforced plastics, since changes in the lay-up design can cause changes in material constants and the design process for an optimum structure becomes an iterative problem particularly suited to solution by digital computation.

The third area where progress is certainly desirable is in the development of production techniques which will change the labour intensive nature of industry. Some progress has already been made in the design of impregnating machines to deal with cloth. However, there is still a vast expenditure of labour consolidating the laminates and further development in this area would make composite materials economically more attractive. It is likely that the highest quality materials requiring precision in lay-up will always be expensive and in many instances it may be cheaper to use a larger quantity of lower quality composite. Ideally the cost factor should be built into the design process when evaluating various laminate compositions.

Conclusions

This review of reinforced plastic indicates that the use of these materials should take careful account of their limitations as well as their advantages. Wherever possible designs should be thought out in terms of composite materials rather than using them simply as a replacement for conventional structural materials but with the limited experience available of reinforced plastics in structures this is an ideal which is seldom achieved at present. It is quite clear, however, that a better understanding of the behaviour of composite materials is already leading not only to more efficient use of existing materials but also to developments in fibres and matrices which will surmount some of the shortcomings outlined above.

A TECHNIQUE FOR RECORDING THE FILTERING ACTIVITY OF MARINE INVERTEBRATES

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Introduction

The problem of detecting filtering activity in invertebrate filter feeding organisms has been of interest to biologists for many years. A number of techniques have been used (Hogarth and Trueman 1967, Morton 1969) but they nearly all suffer from the disadvantages of either requiring apparatus to be attached to the specimen or they are not sensitive enough to detect the small currents set up. The technique described below is not subject to these difficulties, no attachment is required to the specimen under test and the apparatus can be made extremely sensitive.

Apparatus and Method

The principle upon which the detection unit is based is that shown by Sawyer *et al.* 1965. When sea water flows over the cathode of a simple galvanic cell there is an increase in the electrical current passing between the electrodes. The electrical current increases with the increase in speed of flow.

The apparatus consists of a simple galvanic cell of copper and steel connected directly to a 0 - 1 milliamp DC recording milliammeter. The anode is a 15 × 10 cm mild steel plate and the cathode a flat coil 1 cm diameter of 0·4 mm diameter copper wire. To prevent contamination, the anode and cathode were placed in separate compartments connected electrically by a microporous rubber window (See Fig. 1). To record the filtering activity of bivalve molluscs such as *Mya arenaria*, a polythene tube was placed so that the siphons could slide unimpeded up and down the tube and the cathode was positioned at the distal end.

When the same apparatus was used for detecting the siphonal currents in *Teredo* it was found necessary to amplify the electrical current in order to detect the very small variations caused by the small water movements. In this system the steel/copper galvanic cell produced a variable base line due to the unstable corrosion potential of steel. This unstable potential causes variations in the

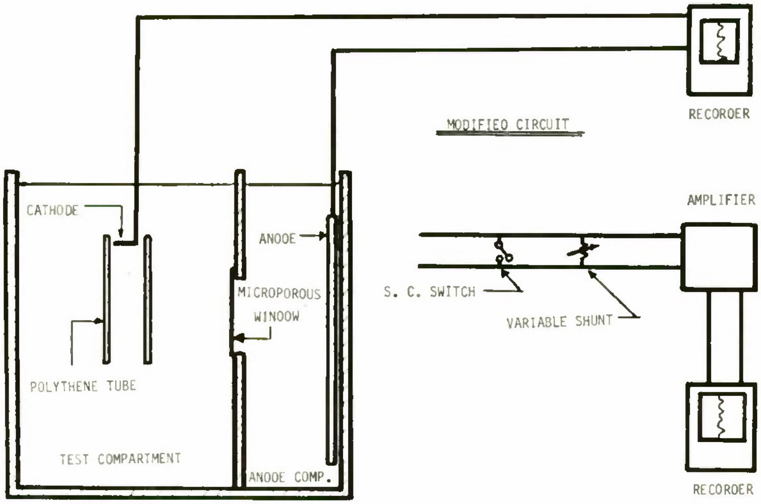

FIG. 1. Schematic sketch of apparatus.

electrical current which although insignificant in relation to those produced by the relatively large water movements of the *Mya arenaria* are of the same order as those produced by the *Teredo.*

After experimentation it was found that by using a copper/platinum couple these difficulties were overcome, so an anode consisting of a flat coil 1 cm in diameter of 0·4 mm diameter copper wire and a cathode consisting of a flat coil 1 cm in diameter of 1·25 mm diameter platinum wire were used. For other work requiring greater sensitivity, platinum cathodes made from fine wires and coiled into discs of various smaller diameters were used.

To increase the flexibility of the instrument and remain within the range of the recording milliammeter it was necessary to use a 0 - 10 K Ω variable resistance as a shunt which could be adjusted to record within the limits of the equipment. To protect the equipment whilst setting up and during the stabilisation period from overloading, a short circuiting switch was fitted.

Measurement of Filtering Currents

A number of organisms were used to demonstrate the applicability of this technique to filter feeding organisms in general. The largest animal used was *Mya arenaria* which was buried in a small amount of its natural substrate in such a manner that when the siphons were extended they passed up the inside of a piece of polythene tubing 2·5 cm in diameter at the top of which was placed the copper cathode and upon which the jet of water from the exhalant siphon impinged.

The apparatus was set up and left to stabilise over a period of four hours before any recordings were made. A typical trace of an active period is shown in Fig. 2.

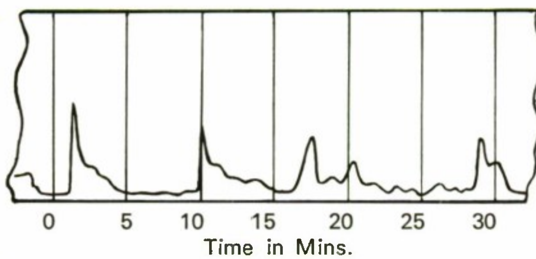

FIG. 2. Typical trace for *Mya arenaria.*

The same basic system was used for measurements with *Teredo* but with the modifications already referred to in the preceeding section. The specimen in this case was contained in a block of wood and a smaller polythene tube of 1 cm internal diameter was used. The trace obtained is illustrated in Fig. 3.

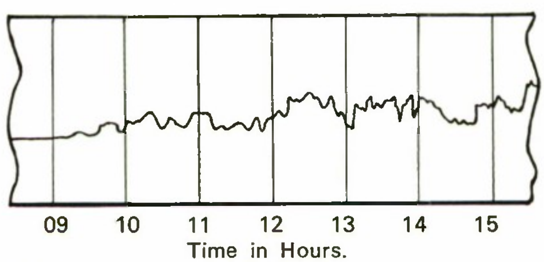

FIG. 3. Typical trace for *Teredo.*

The only modification, for the tunicate *Polycarpa rustica* was the size of the cathode which was a flat coil 0·5 cm diameter of 0·5 mm diameter platinum wire and in this case the polythene tube was unnecessary because of the limited amount of movement of the exhalant siphon. The apparatus was allowed to stabilise for two days before recordings were made, one of which is illustrated in Fig. 4.

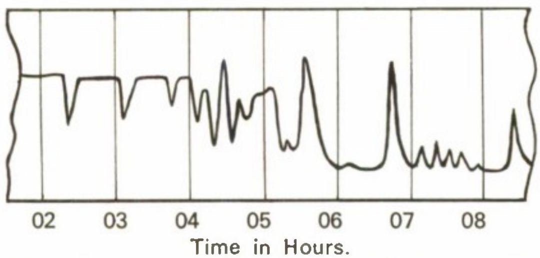

FIG. 4. Typical trace for the tunicate *Polycarpa rustica*.

The same system as used with the tunicate was employed to detect the water movement produced by the barnacle *Balanus balanoides*. In this case the positioning of the cathode was critical because not only was the amount of water flow very small but it was only detectable over very short distances from the opercular valves. Two distinctly different traces were obtained depending on whether the cathode was placed in front of or behind the cirri. These are shown in Fig. 5.

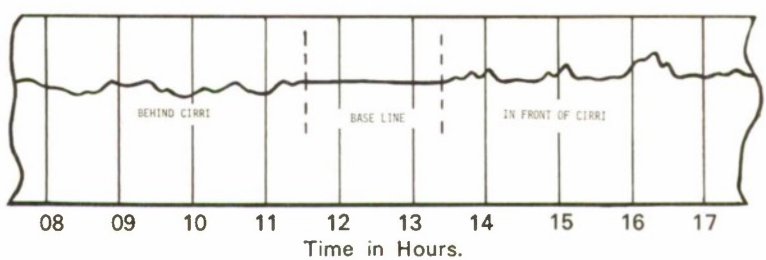

FIG. 5. Typical trace for a barnacle.

Discussion The apparatus has been shown to be capable of detecting and recording the activity of filter feeding invertebrates without the necessity of it being attached to the animal under test. Due to the fact that the exhalant siphons of some of the oganisms such as *Mya arenaria* are capable of a certain amount of movement, it was necessary to constrain these siphons to the limited area covered by the cathode. This was achieved by the use of the polythene tube. It was found in practice that this arrangement gave satisfactory results.

All the traces illustrate that activity can be recorded successfully but no exhaustive programme of study of each of the organisms has been carried out. Rather has it been attempted to show that this method can be applied to any situation in which small currents of water are set up during active phases. The barnacle traces are perhaps the most interesting because of the two distinctly different patterns recorded. The occurrence of a small water flow expelled from the region behind the cirri when the opercular valves open, confirms the observation of Crisp and Southward (1961). The trace produced, however, shows a decrease in electrical current which is the reverse of the condition in all other cases. A possible explanation for this phenomenon may be that as the electrical current is a measure of oxygen availability, the water released is deficient in oxygen thus causing a decrease in the electrical current.

The method has certain limitations in that it does not give a quantitative measurement of the water flow although by calibration at the start of each experiment an approximate value could be obtained. After about a week of use for the copper/steel couple and two weeks for the platinum/copper couple, sensitivity is lost due to the fact that the cathodes need to be cleaned of cathodic chalk. The shunt values have to be changed according to the conditions of the particular experiment, *e.g.* size of cathode, sensitivity required, *etc.*

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EXPERIMENTS IN ULTRA VIOLET PHOTOCHEMISTRY

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Abstract

A device consisting of a special U/V lamp/reaction chamber/detector has been shown to provide a useful monitor of changes in sulphur dioxide concentration but the absolute levels of concentration which could be determined has not been established. This was not part of the basic requirement, but from previously published data it is thought that calibration for absolute measurement should be possible. The performance of the controlled low voltage lamp was examined for possible use as a fluorescence source since its low power requirement improved emission makes it superior to existing units. There is reason to hope that it will be exploited commercially.

Introduction

To capture the transient, and then retain it, has long been the dream of mankind. In the field of photochemistry there has been a generally held belief that advantage could be gained in operating a medium pressure mercury U/V lamp at a point along its ignition cycle where the mercury was neither in its cold cathode nor in its medium pressure mode. The negative resistance characteristic of the impedance of a U/V bulb is a well known fact. Although the work reported here did not set out to explore this phenomena, in practice considerable knowledge of this region has been obtained. Although the work undertaken was primarily for a specific project, the usefulness of the results obtained is not limited to that project alone. Some of the differences between the normal mode of a U/V lamp and the controlled condition of operation are reported.

History

It has long been known that if sulphur dioxide gas is subjected to U/V radiation visible particulates are formed. This effect was reported by Tyndall in the mid 19th century, who gave his name to the phenomenon. Since that time it has been the subject of much investigation and speculation. These investigations have covered a very wide field but much of the work has been performed in relation to atmospheric pollution. Workers in this subject have included Hall, Gerhard and Johnstone, Renzetti and Doyle, Dainton and Ivin and Blacet together with Verzar and Evans. These researchers have shown that the light scattering particulate are normally slow in formation. Renzetti and Doyle[1] and Verzar and Evans[2] have indicated the generation of Aitken condensation nuclei at the same time as the visible particulate formation. Most of the work appeared to confirm that in normal atmospheric conditions the rate of photo-oxidation was primarily related to the sulphur dioxide concentration.

The possibility of relating the particulate population to the concentration of sulphur dioxide, led to a requirement to produce a U/V lamp to create particulates direct from the gas by irradiation. This lamp when followed by a particulate detector could be a sulphur dioxide monitor. If the particulate detector were a continuous sampling device then a constant indication of sulphur dioxide concentration changes, that were independent of the sulphuric acid and hydrogen sulphide concentrations, would be obtained.

Experimental Investigation

The experimental layout comprised a suite of two rooms. Fig. 1. The equipment was in one room, remotely controlled from the other. This comprised two particle detectors, circulating fans, sampling pumps, U/V lamps, room filters and a precipitator. The remote controlled room where the reactions and sampling were done had a total volume of some 60 cubic metres. Solar illumination was excluded by blanking off the windows. Any air entering the room was filtered by an ultra H.E.P.A. filter; this also provided a slight rise in pressure in the sampling room to prevent ingress of contaminants.

The air in the controlled room was sampled by passing the air through the particle detector and returning this air back to the room. Towards the end of the work a U/V lamp and reaction chamber were placed in the air line to one of two particle detectors employed throughout the experiment. The particle detectors were capable of detecting Aitken condensation nuclei in the region of 100Å to 900Å diameter.

The first experiments employed a domestic sunlamp which was allowed to irradiate the whole room. The air in the room was circulated by means of three synchronous fans. The speed of these fans was kept to the minimum required for efficient mixing. By this means all the air in the room was circulated through the beam of U/V radiation every few minutes. Total circulation took about 115 secs.

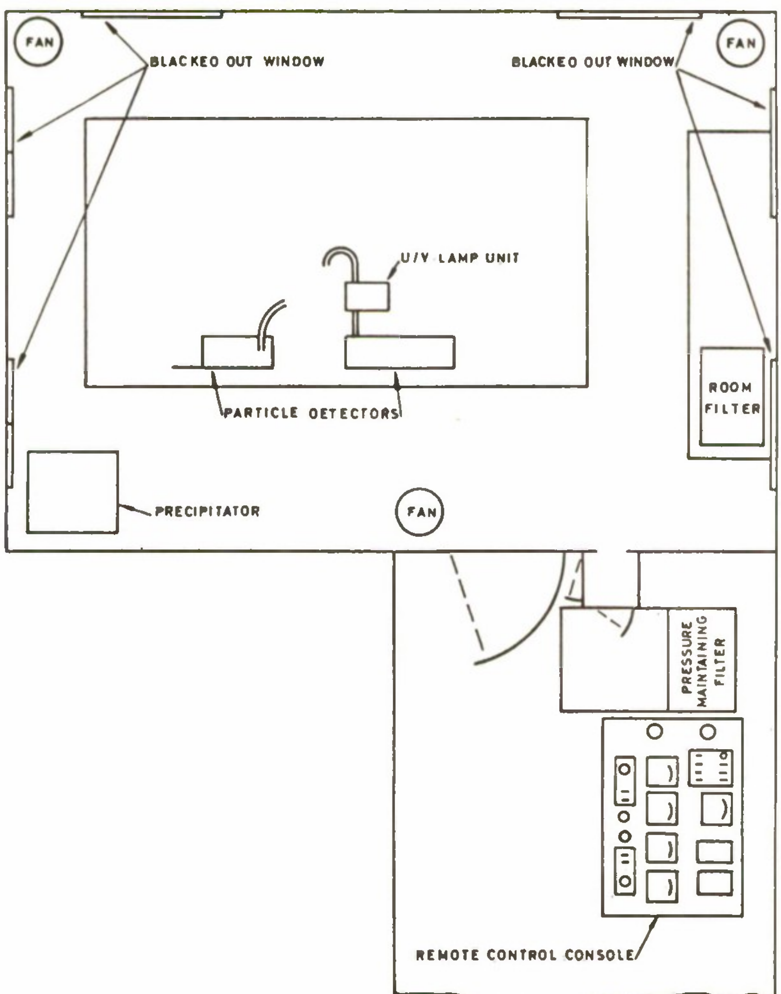

FIG. 1. Layout of Clean Room and Remote Control.

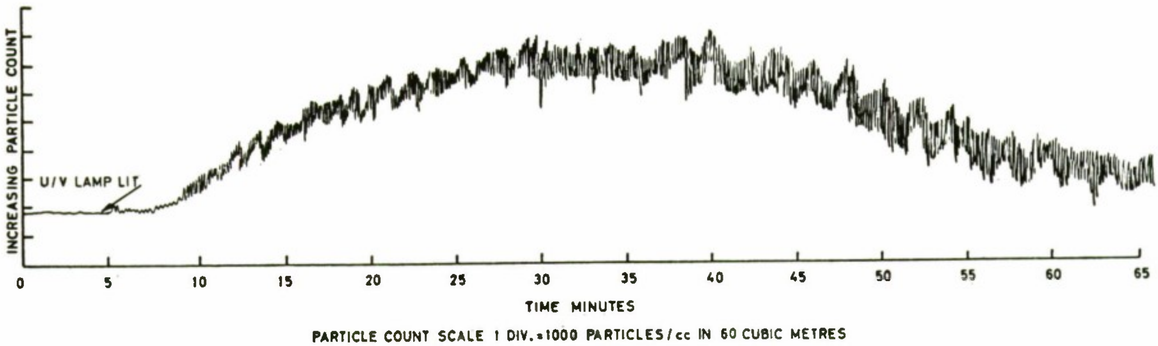

FIG. 2. Domestic sun lamp on room air generally radiated.

The results obtained, Fig. 2, show a slight effect on switching on the lamp although this was not always fully apparent. After a period of about four minutes, the time taken for this lamp to reach full power, a steady increase in particulate count took place. Despite the filter and precipitator it was never possible to remove all particulates from the room air prior to an irradiation experiment, however the residual counts were usually in the order of 100 - 300 particles of the size of 600Å diameter or less. The counts obtained with the irradiation experiments were about 8000 particles per cc of 800Å dia or less. It will be seen from the typical curve given in Fig. 2 that there is a steady rise, after the initial excursion, for about 15 mins., then the level is steady for a similar period and then there is a steady decrease. Switching off the U/V after about 15 minutes of irradiation had little or no effect on the fall off of the particle count. A residual count after about one hour was very slight.

A small quantity of sulphur dioxide approx. 20 ccs was introduced into the sampling room. The particle count with this quantity of gas when irradiated was approximately 30,000 particles per cc. On some occasions the particle count with ordinary atmospheric air could approach 20,000 particles per cc. This usually occurred during the winter when the prevailing wind passed over London or over a local built-up area. The figure of 8000 per cc is average for summer months.

Thorough checks eliminated the origin of the increase in particle count from any source other than the U/V irradiation. Care was also taken to ensure that the sampled air was not taken direct from the irradiated region and where there had been thorough mixing.

A new type of U/V lamp was obtained, which was a more powerful lamp of the ordinary fluorescence type with a OXY9A filter glass over the front. This when tested produced no reaction in the room, even when irradiating the air which was about to enter the sampling detector. Removing the filter glass however produced such a violent effect that the particle counter ceased to function through gross overloading. By desensitizing the electronics by a factor of 100 it was possible to control this increase when the lamp was switched on. By means of a shutter across the lamp opening it was intended to check whether with such a large particle count it was possible to obtain a rapid response to irradiation. With the shutter closed, the lamp was switched on and allowed to reach full power, then the shutter was opened and a reaction chamber attached to one particle counter was irradiated. There was an increase in particle count, but not of the order expected from the previous experience. It was found that this massive increase in particle generation only occurred during the period just after the lamp had been switched on. The particle count needed to produce this violent effect was of the order of 10^6 - 10^7 per cc.

This massive particle count was produced very rapidly because the air sample remained in the reaction chamber for less than five seconds. For the particular research study in progress it was necessary to control the lamp in the condition where the particulate generation was at a maximum. As this appeared to occur just after the lamp was ignited, several bulbs of differing types were examined in this condition. It was found that the "sunlamp" bulbs were more consistent than the fluorescence bulbs when operated under the initial

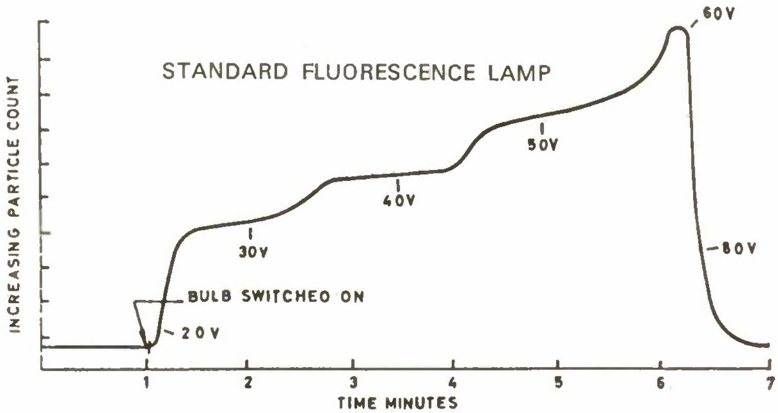

FIG. 3

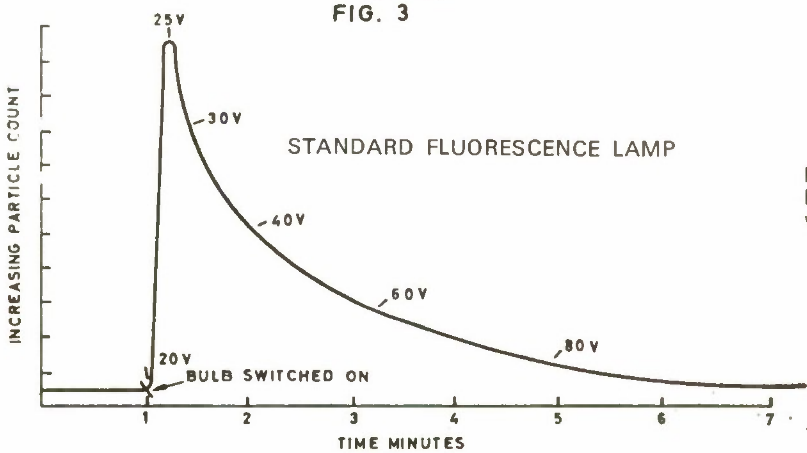

FIG. 4

FIGS. 3, 4 and 5.
Bulb strike and
warm-up characteristics.

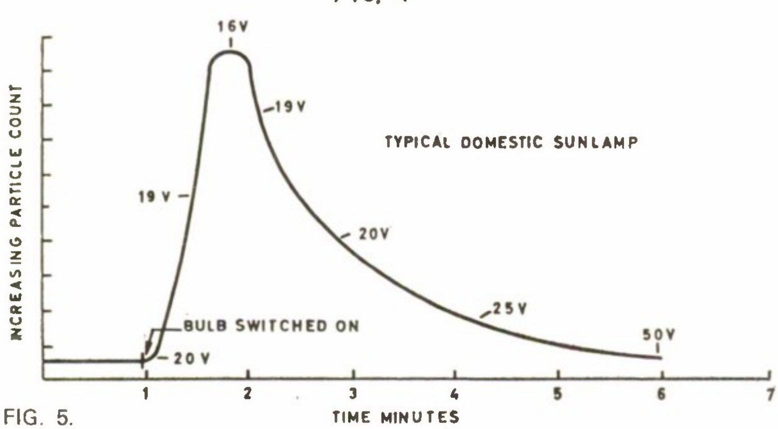

FIG. 5.

strike and warm up conditions. Figs. 3, 4 and 5 show some bulb strike and warm up characteristics; the voltage is that which appears across the lamp terminals when supplied with the correct drive. It will be seen that the maximum effect occurs for the sunlamp at a voltage of about 16 - 19 volts. As the current in the fully struck condition and in this low voltage condition are similar, i.e. 1·1 amps and 1·25 amps respectively, the total power requirement is about 1/5 that of the normal condition.

One common feature of all bulbs tested was that the initial effect did not remain after the lamp was fully struck. When the lamp was fully struck the particle count produced by irradiating a reaction chamber fluctuated in an unsteady fashion, although the sun lamp produced less unsteadiness than the standard fluorescence bulbs. This unsteadiness was also present in the room reaction (see Fig. 2).

After some considerable development work it was possible to control the sunlamp bulb so that it remained with the terminal voltage at 16 - 19 volts. This point coincides with the point of inversion in the impedance characteristic of the U/V arc where the negative resistance slope becomes a positive one. It will be seen from the curve that this operating point is critical.

The method of controlling these bulbs is the subject of a patent application.

With the ability to control the bulb, a lamp and reaction chamber were built as one unit, Fig. 6. The lamp compartment could be flushed either with air or with an inert gas such as nitrogen or argon. This was separated from the reaction chamber by means of a wall containing a window of synthetic quartz.

During the experiments with the lamp unit both the flushing air and the nitrogen were supplied from outside the sampling room and after passage over the bulb in the lamp chamber were returned to be exhausted outside this room. During the bulb warming up period if either air or nitrogen were passed through the lamp chamber there was an increase in the particulate count, the effect being slightly greater with nitrogen.

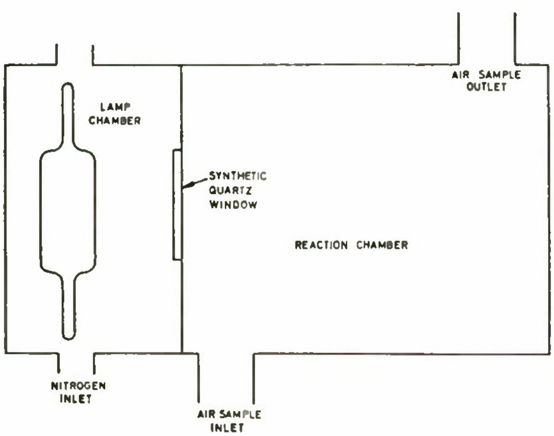

FIG. 6. Plan of lamp unit.

By the time the lamp was proved suitable for the purpose required, considerable quantities of sulphur dioxide had been injected into the test room. On dismantling the particle detector a fine yellowish film was found deposited on a collecting surface. On heating a small area the film sublimed onto a nearby chilled boiling tube. This material when examined under a microscope appeared to be of an irregular crystalline nature, and had the characteristic appearance of elemental sulphur although it was not positively identified. A similar detector not sampling the irradiated air did not show such a film.

The work was not continued beyond this stage since the original objective for the investigation had been achieved.

Discussion The nature of the deposit on the collecting surface has not been positively identified. However from the visual and sublimation evidence it might be concluded that the material is elemental sulphur. Since Tyndall in the 19th century first discovered particulate formation by the action of sunlight on sulphur dioxide a large number of investigations into the effect of U/V on the gas have been made. The form of radiation employed in the experiments has been both natural solar and mercury arc. From the work reported by Hall[3], Blacet[4], Dainton and Ivin[5] some of the following possible reactions of sulphur dioxide could take place under conditions of irradiation:

$$SO_2 + hV \rightarrow SO'_2 \qquad 1$$

$$SO'_2 \rightarrow SO''_2 \ (+M \rightarrow SO_2) \qquad 2$$

$$SO'_2 + SO_2 \rightarrow SO_2 + SO_2 \qquad 3a$$

$$SO'_2 + N_2 \rightarrow SO_2 + N_2 \qquad 3b$$

$$SO'_2 + O_2 \rightarrow SO_2 + O_2 \qquad 3c$$

$$SO'_2 + O_2 \rightarrow SO_4 \qquad 4$$

Dainton and Ivin postulate that the excited state SO'_2 may degrade to a vibrationally excited ground state SO''_2 by means of an internal transfer of energy, which may subsequently be deactivated by collision. Since the observed limit of fluorescence is 2100Å, and as the wavelength employed in the reported work are well above this figure, it must be assumed that the initial excited state may only be deactivated by such an internal transfer of energy

or by collision. In 3 above the reaction $SO_2' + M \rightarrow SO_2 + M$ has been expanded to include some of the gaseous molecules that could serve as M in the deactivation process.

Gerhard and Johnstone[6] found, using bright sunlight, that from 1 and 4 the following reactions could be expected to occur:

$$SO_2 + hV \rightarrow SO_2' \qquad 1$$

$$SO_2' + O_2 \rightarrow SO_4 \qquad 4$$

$$SO_4 + O_2 \rightarrow SO_3 + O_3 \qquad 5$$

$$SO_3 + H_2O \rightarrow H_2SO_4 \qquad 6$$

They found the reaction $SO_2' + O_3 \rightarrow SO_3 + O_2$ is only of minor importance. Leighton[8] also postulates further reaction involving SO_4

$$SO_4 + SO_2 \rightarrow 2SO_3 \qquad 7$$

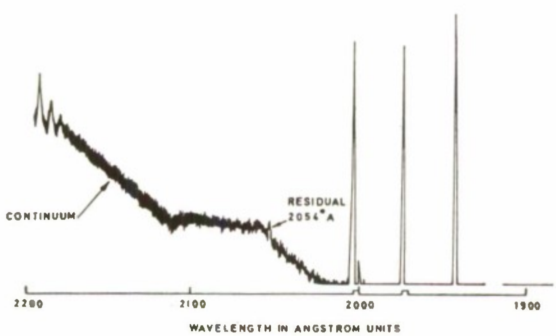

FIG. 7. Normal lamp.

These equations have one major feature in common: in no case is any free sulphur produced. The bond dissociation energy for the sulphur dioxide molecule quoted by Leighton is 135k cals/mole (3) (7)

$$SO_2 \rightarrow S + O_2 - 135k \text{ cals/mole.} \qquad 8$$

This figure is too high to be obtained from solar radiation and he deduces that the reactions 1 - 7 must arise involving activated sulphur dioxide molecules.

From spectral analyses, carried out by Light Division of the National Physical Laboratory of the radiation of the U/V bulb under the two conditions of operation (Figs. 7 and 8) it will be seen that there are bands of radiation present in the controlled condition that are not present in the normal or medium pressure mode. The wavelengths of the new lines are 2263Å, 2054Å and 2028Å. Of these 2054Å has a triple peak. Another feature of the difference in controlled to medium pressure is the absence of any continuum in the controlled condition, the radiated energy being confined to the spectral lines. It may be argued that the advent of the new lines could arise from the spectral shift of three lines which are present in the medium pressure mode but absent in the controlled condition. These lines are at 2259Å, 2003Å and 1973Å wavelengths. The differences between these and the controlled wavelengths are + 4Å, + 51Å and + 55Å, so a simple shift would not meet three conditions. Also from examining the medium pressure spectrum a residual peak in the continuum is seen at the point of the 2054Å triplet in the controlled condition. It will be noted that the strength of this triplet is of the same order as the peaks in the continuum.

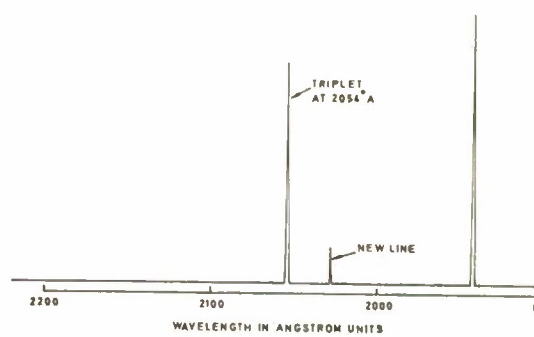

FIG. 8. Controlled lamp.

The longest radiation wavelength with a quantum of energy sufficient to disrupt a sulphur dioxide molecule, is 2100Å.

The hypothesis is put forward that the reaction $SO_2 \rightarrow S + O_2 - 135k$ cals/mole is taking place in the reaction chamber when the U/V bulb is in its controlled condition. The energy in the 2054Å triplet is capable of yielding 139k cals/mole from $\lambda(\text{Å}) = 2{\cdot}86 \times 10^5 / E(\text{k cals})$. In support of this is the film sublimation and microscopic examination of the sublimed material which appeared to be elemental sulphur. In further support is the fact that when the bulb was allowed to irradiate the reaction chamber without being flushed with air the reaction produced was much less than when the bulb was so flushed. A further in-

crease in reaction took place if the flushing air was replaced by an inert gas such as nitrogen or argon. In these latter cases the ozone products around the bulb, which would reduce the amount of radiation in the shorter wavelengths that could enter the reaction chamber through the quartz window, would not be present.

Conclusions A device consisting of a special U/V lamp/reaction chamber/detector has been shown to provide a useful monitor of changes in sulphur dioxide concentration but the absolute levels of concentration which could be determined has not been established. This was not part of the basic requirement, but from previously published data it is thought that calibration for absolute measurement should be possible.

The performance of the controlled low voltage lamp was examined for possible use as a fluorescence source since its low power requirement improved emission makes it superior to existing units. There is reason to hope that it will be exploited commercially.

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Defence Quality Assurance Board

A Defence Quality Assurance Board has been set up jointly by the Ministries of Defence and Technology to be responsible for quality assurance policy and procedures for both Departments, seeing that they are applied uniformly and that quality assurance facilities are rationalised and integrated to the maximum extent. The Board consists of the senior officers of both Ministries who are most closely concerned with the procurement of defence equipment. Its chairman is General Sir Charles Richardson, G.C.B., C.B.E., D.S.O., the Master-General of the Ordnance.

The Board will work through a professionally qualified Chief Executive who will also be a member of the Board. Mr. H. E. Drew, C.B., Director General of Quality Assurance at the Ministry of Technology has been appointed to the post of Chief Executive and will take up his responsibilities on September 1st 1970. Commodore D. G. Spickernell, R.N., Deputy Director of Naval Ship Production in the Navy Department, has been appointed as his deputy.

The establishment of a Defence Quality Assurance Board was recommended by an independent committee headed by Colonel G. W. Raby, C.B.E., Chairman of United Gas Industries Ltd., which studied the Defence Equipment Inspectorates. The Committee emphasised the importance of placing an increasing measure of responsibility for quality assurance on industry and reducing direct Government inspection accordingly. This has been the trend in both Ministries for some time and it will be given new impetus by the setting up of the Defence Quality Assurance Board and implementing other measures recommended by the committee. Increasingly it will be the policy of the Ministries of Defence and Technology to give preference to firms who can show that they have satisfactory arrangements for ensuring that their products are of adequate quality.

THE HELIUM BARRIER AND BEYOND

J. Bevan, M.Sc., R.N.S.S.
Royal Naval Physiological Laboratory

John Bevan (26) has been an Assistant Experimental Officer at the Royal Naval Physiological Laboratory since joining the Civil Service in 1967. Following his graduation with a B.Sc. Honours Degree of the University of London in 1967 he has recently been awarded the M.Sc. for his thesis on neurophysiological aspects of deep diving. Mr. Bevan's involvement in the field of diving extends to his spare time during which he has qualified as a First Class Diver of the British Sub-Aqua Club (BSAC), a National Underwater Instructor, become the Regional Diving Coach for the South of England (BSAC) and a member of the United Kingdom Competition Fin-swimming Team for the last two years.

The existence of a "helium barrier" to free divers was first proposed by Dr. Ralph Brauer (U.S.A.) as a result of an experimental simulated dive to 1190 ft. in 1968.

During this dive in which Brauer was himself a subject, abnormalities in the electrical activity of the subjects' brains, E.E.G., were observed by the attending scientific crew.

The subjects found that during their brief exposure to the maximum pressure they were unable to maintain consciousness if they did not actively indulge in any specific mental or manual task. This peculiar lapsing into a state of sleep they termed "micro-sleep" and this together with the E.E.G. abnormalities led the attending scientists to assume that the symptoms could be precursors of more dramatic events including epileptiform convulsive seizures. For these reasons the experimental dive was prematurely brought to a conclusion —after only four minutes at 1190 ft.

Brauer's dive was a French-American combined effort executed at Marseilles, France. British opinion of the results of this experiment was that the crisis at depth could have been avoided if a different technique of compression had been employed.

In the following year we carried out a similar dive at the Deep Trials Unit at the Royal Naval Physiological Laboratory (R.N.P.L.) as an Anglo-Swiss combined venture. The dive was to a simulated depth of 1150 ft. and the three Swiss divers performed both manual and mental tasks equally well at depth as they had previously on the surface, neither did they suffer from the condition referred to as "micro-sleep". The divers also performed heavy physical work under-water in the wet-section of the compression chamber complex whilst at maximum depth with no apparent adverse signs. The success of this experiment at a depth only 40 ft.

shallower than Brauer's 1190 ft. dive tended to confirm the opinion held at R.N.P.L., and considered together with supporting data from animal experiments it was reasoned that it should be possible to penetrate the so-called helium barrier.

At about this time a new high-pressure chamber facility was installed at R.N.P.L. with a simulated depth capability of 2250 ft. It was decided that a programme be drawn up for the preparation of this new chamber to perform a dive to 1500 ft. to test the validity of the proposition of a helium-barrier.

Human subjects were to be used and the scientific instrumentation, experimental and monitoring techniques were to be prepared and checked for operational use.

Approximately one year's work was involved in the preparation for the dive with many problems arising and being resolved. Amongst these were the sheer mechanical difficulties of ensuring that the high pressure gas connections and associated valve systems of the chamber were absolutely fail-safe and that the electrical compatibility, safety and stability of the instrumentation were satisfactory. Much of the instrumentation had to be designed and constructed specially for the dive, due to the unique conditions to which they would be exposed, including high humidity, high oxygen partial pressure, high hydrostatic pressure and high fire risk.

During this time a volunteer team of potential subjects was "worked-up". The team consisted of civilians of the R.N.S.S. employed at R.N.P.L. who were all Royal Naval qualified divers, experienced in compression chamber diving and who were familiar with the techniques and instrumentation employed in this type of research. These qualifications were essential to the success of the dive for several reasons. They ensured the availability of the subjects over a long period (12 months) for the testing of their baseline physiology and for their thorough familiarisation with the instrumentation both inside and outside the chamber. Thus should any failures occur in the equipment during the dive the subjects could double as technicians and perform the necessary repairs or the installation of stand-by instruments.

Two subjects were to be picked from the team to undertake the dive and it was Peter Sharphouse and myself that were ultimately chosen. We were both very fit and had over the preceding months carried out systems-testing, procedure-checking and work-up dives down to 450 ft. A vast quantity of base-line physiological data concerning the performance of our bodies had been obtained during many days confinement in compression chambers.

As the "big day" approached, Peter and I busied ourselves making final domestic arrangements in preparation for our projected 14 days in the compression chamber. Peter who is married and has a very young daughter was much busier than myself at this stage since the only preparation I had to make as a bachelor was to cancel my milk delivery for a fortnight!

On the morning of March 3rd, Peter and I reported to R.N.P.L. at 0800 hours when final preparations for the dive began. Three areas were shaved on our heads, each about two inches square, where small silver electrodes were to be attached. These electrodes were to be responsible for detecting our E.E.Gs. Next our chests were bared and shaved for the attachment of more silver electrodes. These would be responsible for detecting our heart and breathing activity.

We eventually entered the lock of the compression chamber at 0930 hours. The procedure of the dive first of all involved the substitution of an oxy-helium mixture for the air in our chamber. To do this we breathed from special "gas-masks" whilst the gases around us were changed. It was at this point that we experienced our first set-back. There had been an undetected leak from one of the helium gas cylinders into our breathing supply. This meant that the mixture we finally breathed had too little oxygen. Peter became unconscious within about five minutes and I was beginning to feel peculiar. I sounded the alarm and within seconds I heard the hissing of good pure fresh air entering our chamber and I abandoned my gas-mask and its contaminated gas supply. Peter had lost his mask when he became unconscious and soon regained consciousness. The chamber door re-opened and we both stepped out.

There was a very real feeling of disappointment in everyone's mind as we strolled around awaiting the results of the checks. If the fault was to prove to be a major one, then our dive, which we had been preparing for so long, would be postponed for a considerable time. Fortunately, when the faulty and contaminated gas cylinders had been identified, only a small number were found to be involved and the decision was made to go ahead as planned, apart from running about one hour behind schedule.

The second attempt to begin the dive was more successful and Peter and I transferred from the lock into the main chamber at 50 ft. We stayed at this depth for one hour during which time we were very busy connecting up and checking various instruments. With all systems functioning well, the dive continued to 600 ft. where we were to remain for the next 24 hours. Most of our waking time was spent performing tests and providing "outside" with voluminous quantities of physiological information. Whilst I would be carrying out one task such as a hand-eye co-ordination test, Peter would be performing another such as a mental arithmetic test.

The second day closely followed the pattern of the first, except that the depth was now extended to 1000 ft. where we were to remain the next 24 hours.

The third day was one of the most interesting since on this day we had planned to exceed the **"helium barrier".** We were to do this slowly, carefully feeling our way. The first move was to 1100 ft. where a pause of one hour allowed us to acclimatise and to perform another barrage of tests. The next move was to be to 1200 ft.—to the helium barrier and beyond. We sat there in our little chamber, backs to the wall, wondering how we would fare. When the descent was resumed the temperature inside the chamber rose, as it had each time the pressure had increased. The humid atmosphere coupled with the rising temperature caused us to perspire profusely and as I wiped the beads of sweat from my forehead I once again noticed the awkward jerkiness of my efforts induced by the helium tremor with which I had been affected for most of the dive. Inquisitive pairs of scientific eyes peered through the tiny portholes in our chamber, observing our every move. When the hissing of the incoming gases stopped we knew we had just become the two deepest men in the world—*we had penetrated the helium barrier !*

We felt eager to go deeper but stuck rigidly to our schedule of testing and re-testing. We were only 10 ft. deeper than the last record-breaking dive (1190 ft.) but we had another 300 ft. to go.

Following a stay of one hour, crammed with tests, at 1200 ft. we proceeded to 1300 ft.—over 100 ft. through the **"helium barrier"** and still everything looked good for the final plunge to 1500 ft. This was to be after a further 24 hours had passed and so we contained our curiosity and concentrated on the day's schedule of tests.

The fourth day was our "big day". We went from 1300 ft. to 1400 ft., checked and re-checked everything and finally after one hour at 1400 ft., progressed to 1500 ft. The descent went perfectly. Unfortunately there was very little time for festivities as the next 10 hours were occupied with an exhaustive programme.

At the maximum depth of 1500 ft. I recalled the list of possible problems we thought may have hampered the progress of the dive. We did not suffer from any breathing difficulties but the greater "thickness" of our atmosphere was quite appreciable. The effect of temperature changes was quite surprising. The most comfortable temperature was at 30°C, but if it fell or rose by only 1° then we would quite quickly feel too cold or too hot. It would appear that this will be an exteremly important factor to be reckoned with in future deep diving. "Helium tremor" occurred in myself but not to any significant degree in Peter. Even so, we were both capable of performing work perfectly adequately. Happily, we found that no "micro-sleep" or convulsions occurred.

With perhaps the most successful 10 hours of British deep diving behind us, somewhat nostalgically, we began the very slow ascent to the surface. A slow ascent was necessary to avoid the "bends" or decompression sickness. This occupational hazard is a sickness peculiar to workers in unusual pressures such as pilots, astronauts or divers and its cause is the production of gas bubbles inside the tissues of the body. Its symptoms vary from a slight itch, to considerable pain or even complete paralysis.

At midnight we rolled out our sleeping bags and settled down for a good night's sleep. Two hours later, Peter woke me up and complained of feeling very dizzy.

Decompression sickness had reared its ugly head and struck at Peter's sense of balance. Soon Peter was vomiting and finding it impossible to determine which way was up or down. Our ascent was stopped and in an effort to relieve the disturbing symptoms in Peter we began to descend back towards 1500 ft. As the pressure about us was slowly increased I suddenly became aware of a very subtle change appearing in myself. I was beginning to feel warm and drowsy. I reported this immediately and in the ensuing minutes the sensation increased to such a level that I was finding it

difficult to remain conscious. With increasing difficulty and incoherence I continued reporting as objectively and accurately as possible on the progress of my condition to the "outside". Instinctively I turned to do anything I could to keep myself from succumbing. I flexed my muscles, tidied up the chamber, crawled around and even tried forcing sharp objects against the sole of my foot. By this time we were being once again brought towards the surface in order to remove the condition now appearing in myself. This therapeutic action was successful and I was soon back to normal. Peter, however, remained as sick as ever.

Peter's condition had been seen in divers at relatively shallower depths and had been found to disappear over a matter of days, happily this was found to be the case, but during those first few days of our ascent Peter had a pretty rough time being in an almost perpetual state of dizziness and unable to eat any solid food. It was with considerable relief that I observed his appetite and sense of balance return. When his wife and daughter visited the laboratory during the ascent phase he had almost completely recovered.

Our ascent was to last a total of 12 days—two days longer than first anticipated due to the occurrence of decompression sickness. We continued our tests throughout this time but following a not so quite intensive programme. This allowed us more leisure time which we spent mainly reading, writing letters and drawing cartoons.

With only three more days to go before we were to "surface", decompression sickness struck again and this time it was my turn. My right leg had begun to ache around the knee and in a matter of minutes it turned into an uncomfortable pain which seemed to be increasing all the time. Our ascent was stopped and once more we began to descend in an attempt to alleviate the condition. The depth at this time was sufficiently shallow to permit the use of pure oxygen which is renowned for its therapeutic qualities in treatment of the "bends". Rather sadly, the treatment was unsuccessful and it was decided to resume our ascent and after a short time the pain eventually dissipated.

We surfaced at 1600 hours, Wednesday, March 18th, 1970. Peter was virtually fully recovered from his complaint and all that remained of mine was a very slight residual ache. The reception we received when we emerged from the chamber was an almost overwhelming experience. We had never imagined that so many people would have been waiting to see us climb out. This very happy occasion was, however, very brief since we were required for an immediate and intensive medical examination and to provide further blood samples for analysis.

Within a few days my leg had completely recovered and the only after-effect of our dive that I could detect was a slight reduction in general muscle tone, mainly in my legs. Within three to four weeks however I was back in competition fin-swimming condition.

Our dive to 1500 ft. at the Royal Naval Physiological Laboratory was a great success. The descent to maximum depth has shown that man can not only survive but even work in reasonable comfort under these pressures. The incidence of decompression sickness during the ascent merely indicates that a different decompression schedule is required and such modifications are fairly easily accomplished. This therefore does not present a major difficulty to future deep diving.

We both feel that we can go deeper with safety. The existence of the helium barrier is confirmed, but it can be penetrated if a slow compression rate is used. It remains an arduous task to attempt to predict where the limit to deep diving lies. It could be presented in the region of 2000 ft. for oxy-helium breathing divers due to the increased density and viscosity of the gases breathed. It would certainly seem that our knowledge of respiratory physiology at increased pressures is becoming increasingly important in the effort to determine the depth capability of man and that careful temperature regulation of the diver's environment will be a further crucial factor in the success of future deep diving.

In conclusion we would like to pay tribute to the team at R.N.P.L. whose work made this achievement possible and especially to Dr. H. V. Hempleman (Superintendent, R.N.P.L.) and Dr. P. B. Bennett (Scientific Co-ordinator). Our high morale throughout the dive was directly attributable to the complete confidence which Peter and I had in the supporting team, without which such a dive would certainly have been impossible.

THE MASSES OF THE PROTON AND NEUTRON

And a Conjecture for the Gravitational Constant

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Ten years ago[1] I pointed out that the expressions

$$137^2/10\gamma = 1836{\cdot}098 \text{ (or } 136^2/10\beta = 1836{\cdot}099) \text{ and } 46^2/10\gamma = 207$$

give the masses of the proton and of the mu meson, in terms of the electron mass m_e within experimental error, where β is Bond's constant $137/136 = 1+2/(16{\cdot}17)$ and γ is Good's constant $46/45 = 1+2/(9{\cdot}10)$. E. Richard Cohen, the authority on physical constants, has informed me that an equally good value for the proton mass m_p was published by Lenz[2], with the remarkably simple formula $6\pi^5 = 1836{\cdot}118$. The currently best estimate is

$$m_p/m_e = 1836{\cdot}109 \pm {\cdot}011$$

so both pieces of numerology are still within experimental error.

It seems to me that Lenz's formula, when combined with some further observations, is strong evidence that there is something in Eddington's Fundamental Theory. In this theory the question is raised "How many particle-points occupy a certain volume of phase space?", where the phase space in question has $R_2 = 10 = 2^2(2^2+1)/2$ real and $I_2 = 6 = 2^2(2^2-1)/2$ imaginary dimensions[3]. Also there is a double phase space that has $R_4 = 136 = 4^2(4^2+1)/2$ real dimensions and $I_4 = 120 = 4^2(4^2-1)/2$ imaginary ones. The volume of a unit ball (spheroid) in the phase space is $V_{10} = \pi^5/120$ so that Lenz's estimate for m_p/m_e can be written in the interesting form

$$m_p/m_e = I_2 I_4 V_{10} \qquad \ldots (1)$$

within experimental error.

Eddington[4] wrote $\beta = 137/136$ since he believed that the fine-structure constant was equal to $1/137$. The current estimate, however[5], is $\alpha = 1/(137{\cdot}03602 \pm {\cdot}00021)$. Let us therefore write $\beta' = 1/(136\alpha)$ and note that $V_{10}/\beta' = 2{\cdot}530884 \pm {\cdot}000004$. It is remarkable that $(m_n - m_p)/m_e = 2{\cdot}53090 \pm {\cdot}00025$ so that, within experimental error,

$$(m_n - m_p)/m_e = V_{10}/\beta' \;. \qquad \ldots (2)$$

By eliminating V_{10} we can also write $m_p/(m_n - m_p) = 725{\cdot}48 \pm {\cdot}06$ and $I_2 I_4 \beta' = 725{\cdot}4848 \pm {\cdot}0011$ so that, within experimental error,

$$m_p/(m_n - m_p) = I_2 I_4 \beta' \;. \qquad \ldots (3)$$

These results seem too striking to be regarded as a mere coincidence.

It is tempting to indulge in some speculation. The quadruple phase space should have $R_{16} = 256 \cdot 257/2 = 32896$ real and $I_{16} = 255 \cdot 256/2 = 32640$ imaginary dimensions. The volume of a 136-dimensional unit spheroid is $V_{136} = \pi^{68}/68$! so, by analogy with formula (1), there might be a particle whose mass is either $m_1 = I_2 I_4 I_{16} V_{136} m_e$ or $m_2 = I_4 I_{16} V_{136} m_e$ or $m_3 = I_2 I_{16} V_{136} m_e$, although m_3 seems a little less likely to correspond to reality than m_1 or m_2. Since $I_2 I_4 I_{16} V_{136} = 6 \cdot 06 \times 10^{-55}$, the particle would be expected to have a diameter about 10^{-18} times that of the electron, and therefore about 10^{-31}cm. It might have something to do with the five-dimensional theories in which the radius of the universe in the fifth dimension is of the order of 10^{-30}cm[6]. Note too that Wheeler (for example[7]) suggests that space might be permeated with "worm-holes" with diameters of the order of $\sqrt{(Gh/2\pi c^3)} \sim 10^{-33}$cm, where G is Newton's constant of gravitation.

An interesting dimensionless constant is

$$\sqrt{(hc/2\pi G)}/m_3 \simeq 3 \times 136 \times 2^{256} \quad \ldots (4)$$

which is double Eddington's estimate for the number of protons and electrons in the universe: I have presumably included the antiprotons and positrons! Using the values given in [5], the left side of (4) is $(4 \cdot 72776 \pm \cdot 0011) \times 10^{79}$ and the right side is $4 \cdot 72432 \times 10^{79}$ so the discrepancy is 3·1 standard deviations. It seems to me that the degree of agreement is better than the degree of disagreement, especially as published values of the standard deviations of physical constants are often too low. Moreover, since $m_n = m_p \left(1 + \frac{1}{I_1 I_4 \beta'}\right)$, it might not be too *ad hoc* to write $m'_3 = m_3 \left(1 + \frac{1}{R_2 R_4 \beta'}\right)$.

Then

$$\sqrt{(hc/2\pi G)}/m'_3 = 3 \times 136 \times 2^{256}, \quad \ldots (5)$$

the error being only one part in a million if the best current experimental values for h, c and G are assumed. If (5) is exactly true then the published standard deviation for the experimental value of $G = (6 \cdot 6732 \pm \cdot 0031) \times 10^{-8} \text{cm}^3 \text{g}^{-1} \text{sec}^{-2}$ can be reduced to ·00006. On the other hand, if (4) is correct, we would have

$$G = (6 \cdot 68293 \pm \cdot 00006) \times 10^{-8} \text{cm}^3 \text{g}^{-1} \text{sec}^{-2}. \quad \ldots (6)$$

Another speculation is that analogues of the Schroedinger and Dirac equations should be examined in spaces with 10 real and six imaginary dimensions, with 136 real and 120 imaginary, and with 32896 real and 32640 imaginary dimensions. Also perhaps the elementary particles have properties related to the spherical harmonics on the "surface" of a ten-dimensional spheroid.

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DISPLAY DESIGN FOR NAVAL RESEARCH

Part 2. Development and Production

A. R. Colberg
Technical Illustrators Pool (Naval)

Part 1. Purpose and Presentation dealt with the purpose planning and organisation of an "Open Day" exhibition and concluded with a general description of a "Standard Unit" display: This article continues with the development and production of "Open Day" material. As mentioned in Part 1, it is accepted that the services of Manager Technical Illustrator Pools (M.T.I.P.(N)) Design Section will be employed throughout an "Open Day" production period, hereafter referred to as the Design Section.

Steering Committee

The Steering Committee of the particular establishment requiring an Open Day exhibition, should aim at the compilation of a complete 'schedule of exhibits' at the *earliest opportunity*. The 'schedule' can only be produced after consultation with department or divisional officers who are requested to submit requirements for displays. Generally, the Steering Committee will endeavour to keep the number of displays to a practical level and, in some cases, will define a general limit to all departments. It is desirable, at this early stage for the Committee to carefully consider the productive potential of the establishment related to the number of exhibits. These considerations are directed towards photographers, workshops, drawing offices and other services which may be required for production. A critical path diagram is also required covering *all* aspects of the 'Open Day'. This does not come within the scope of this article.

A copy of the 'schedule' is passed to the Design Section who transcribe the display requirements into their own 'production control' book which contains stereotyped pages providing entries for all component items of the displays. (A pro-forma of the page can be supplied to establishments if required, which will enable their 'production unit' to maintain a comparative control). At this stage the establishment should have organised their own 'production unit' and alerted the workshops and other services.

Production Unit

The Unit will be responsible for accepting layout drawings from the Design Section and for producing the final display boards. This will require the marking-out of boards; painting (in colours specified), painting and fixing cork relief letters; fixing photographs, captions, diagrams and text (reading matter). Establishments vary in the choice of personnel for the 'production unit'. Past experience has shown that the Drawing Office forms the nucleus and in some cases the entire 'unit' personnel. Whoever is selected should be adaptable and capable of producing work which is different from their normal duties. Generally the D.I.Y. enthusiast adapts quickly to the requirements of the 'production unit'. Sufficient working space should be allotted for this important task, with provision for assembly benches or tables (these can be purpose-made using "Dexion" angle and timber). An essential piece of equipment for the 'production unit' is a telephone! As the work progresses,

there will be a constant need to maintain contact with the Design Section and other service departments. The Design Section personally offer advice and guidance on all the above mentioned requirements before production commences.

A typical Production Unit at work.

The Co-ordinator

Having established the 'production unit' and other services it remains for a co-ordinator to be appointed at the establishment. This is a key position in the organisation for an 'Open Day' where all associated work demands, display requirements, special items and stores have to be controlled. The duties can be delegated to assistants but it is preferable to maintain overall progress through one person. Normally the leader of the 'production unit' maintains a liaison between the co-ordinator and the Design Section for all display requirements.

The selection of the officer for the role of co-ordinator usually presents a problem to the particular establishment, for it must be appreciated that the duties will quickly become full time. The establishment that recognises the extra work load commitment and is prepared to give priority to the 'Open Day' demands, is the one that succeeds. Obviously, the amount of display material will govern the time factor together with the other services and facilities for such an exhibition. The average time factor can be nine to 10 months overall! To the establishment that has not organised an 'Open Day' on professional lines (using the services of M.T.I.P.(N)), this may appear excessive—they may be further surprised to learn from other establishments who have produced 'Open Days', "we only just made it in time!".

Display Requirement

The 'schedule' of exhibits having been prepared at an early stage is now referred to for progressing the display boards. The 'schedule' will show the proposed title, a brief description of the exhibit, and possible requirements for diagrams or special features. To a sponsoring department this first stage may be considered easy—because it is a question of providing a guide and an estimate of display content—it becomes more difficult when the 'ideas' have to be crystallised into detail.

A completed Standard Unit display.

Experience has shown the detail stage to be a problem to many sponsors when they are called upon to provide the information for the Design Section. At this point it would be useful to explain the process which follows the receipt of this information. As the ultimate product will take the form of a display board, which is visual, a layout drawing has to be prepared based on the technical information provided. When this is completed it is passed to the sponsor for approval and then used by the 'production unit' as a working guide for painting, setting out the component parts (photographs, text panels, diagrams, *etc.*).

The problem that many sponsors face is, what to say and how to say it. They are naturally conversant with their own subject and

could produce a detailed paper running to many pages—but the requirements of a display board would appear to be unsurmountable! The Design Section have often been asked "What do *you* want us to provide?", "Is this what *you* want?" The Design Section's concern must be that of *design* and the *presentation* of material and information; therefore the answer should be, "state what *you* wish to say about the subject with which *you* are conversant—we will transform the requirements into display form". Wherever possible members of the Design Section meet the sponsors to discuss these matters and advise on methods or treatments of the subject in hand. Some sponsors feel that they have to provide the detail *and design the display*! The latter is not so. The question of overall size should be left to the Design Section and not specified by the sponsor. There have been cases where sponsors have asked for 30ft. displays which ultimately become 8ft. with room to spare!

The Brief

A 'brief' can be provided in written form entirely specifying text, captions, photographs, diagrams, *etc.* using a simple key diagram for the relevant disposition of these items. The tendency to 'design' occurs when a sponsor puts his ideas down on paper in sketch form (a natural way of thinking) this is acceptable for *guidance only* as the designer is responsible for presenting the final display. Where a logical sequence is desired it must be stated in the original 'brief' and the designer will incorporate this in the display.

Designing, in the context of display is the disposition of visual units within a given area and this requires details of sizes—and in certain cases weights—of the graphical items. Normally the designer will request copies of photographs, diagrams, drawings, *etc.*, for this purpose of allocating space. Little progress can be made by saying "it's roughly this size" or "it might be approximately so much by so much". *The specific detail must be given.* In certain cases the sponsor may not have the details to hand at the time of writing his 'brief'. This is the exception to the foregoing principle and the designer may suggest and make allowance for eventual size and subject. What is important for the designer at the 'brief' stage is the *full knowledge of all the information* to be displayed. It is frustrating and time consuming to be told at a much later stage "Oh! I forgot to add this or that", "I thought you knew I wanted this". Designers are competent but not to the extent of being clairvoyant! The Design Section will give every assistance in the guidance of providing 'briefs' and suggesting various ways of "getting the message across". This is their job.

Vetting Committee

When the 'briefs' are completed by departments they are passed to a 'Vetting Committee' for approval. The Committee is normally chaired by the Head of the Establishment and they are responsible for maintaining the 'message' of the establishment, whilst attending to security and policy aspects. The direction of all display material through this Committee, provides the Design Section with a single receiving outlet and should prevent unofficial requests coming direct from departments. It is essential that a central control be established, to prevent a chaotic situation developing. The Design Section would only commence preparation of layouts when they receive 'briefs' from the 'Vetting Committee'. It is not always necessary for the Committee to approve the layout when completed, as this is passed direct to the originating department.

The matter of control is important for the smooth progression of production and the necessity becomes apparent in the last stages of completion, when some departments wake up to the fact the 'Open Day' is near and place excessive demands on the 'Production Unit'. It is natural for persons unaccustomed to the complexities of exhibition work to think *there is plenty of time,* especially when the work commences *10 or 12 months* in advance of the 'Open Days'.

Word Content

The basic purpose of 'Open Day' displays is to provide technical information in a straightforward and clear way, which can be assimilated by the visitor without difficulty and without wasting valuable viewing time. This cannot be achieved by assaulting the viewer with large amounts of reading matter and complex diagrams. Conciseness is the order of the day! If the normal supporting publications are provided—the brochure and the handout—these should cover the more detailed aspect of the subject and permit the *display* to *summarise* the principle. The Design Section have always respected the complex nature of

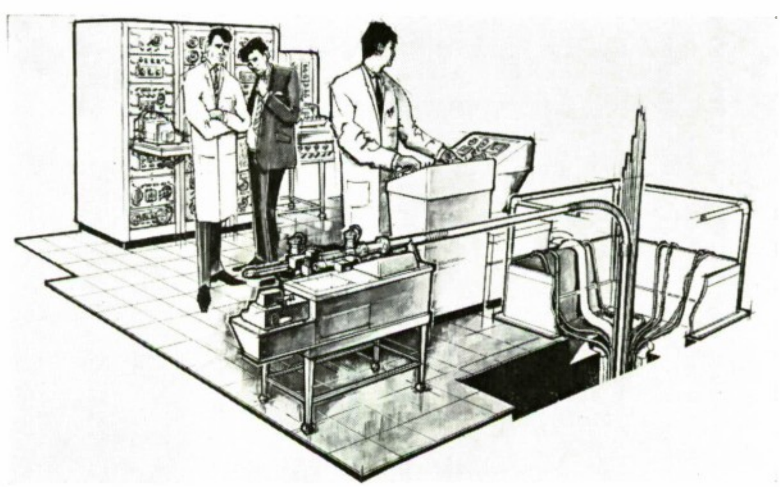
the R & D subjects and the expert knowledge of the scientist who has spent a lot of time on a project. To ask him to sum up in 50 words the hard work and research that has been carried out over a long period of time, may at first sight appear to be inconsiderate. Nevertheless, it has been done and often to the surprise of the scientist ! The author recalls a particular sponsor who was responsible for an apparent complex process and when asked to reduce the product into simple terms replied " From A, B and C are extracted to produce D ". The complexities occurred between the stages of transition; the analysis could fill many reports composed of much formulae and thousands of words—but he did resolve the matter into simple statements. Some sponsors do not take kindly to this which appears to over simplify their efforts and reduce their status. Surely a visitor would congratulate them for their expertness and their ability to state concisely what they have achieved. Finally, in the matter of word content, this should be supplied in *typewritten form* to obviate spelling mistakes and allow the designer to calculate ' copy '.

Pictorial Content

Photographs, diagrams, drawings and sketches are essential units of a display to maintain conciseness and explain complex matter '*A picture is worth a thousand words*'. When considering the selection of photographs; they should be of good quality in definition and contrast, the subject should be clear and not lost amongst irrelevant detail; where possible a negative should be available. Where large machinery or equipment is shown, a person or persons should be included to give scale comparison. Colour photography can also be used either in print form or as a transparency. Reproduction direct from printed matter should be avoided as the result is usually poor and the half-tone screen is prominent. Where photographs are not available and have to be produced to order; this can be an advantage for the designer to advise on the angle and composition to suit the subject. The duplicate photographs, which are called for by the Design Section, are usually produced as 10in. $\times$ 8in. prints although other sizes can be used. Generally, most photographs will be enlarged on the display to provide interest and give the visitor a clearer picture of the subject, where specific detail needs to be shown.

Diagrams, drawings and sketches will also be treated photographically and similarly enlarged.

Additional effects can be obtained by photographic processing; reversing the drawing as white lines on black, or, by the addition of colour when the print is complete. Diagrams are produced by the establishment drawing office or by the M.T.I.P.(N) Studio. Certain technical detail, which is not suitable for direct



Artist's impression of an experimental laboratory produced by the M.T.I.P. (N) Studio.

photography, can be prepared as a cut-away drawing or an artist's impression by the M.T.I.P.(N) Studios. Again the Design Section can advise on the suitability and treatment of subjects for photography and artwork.

Hardware and Samples

The 'Standard Unit Display' is of three dimensional form constructed from square steel tubing, including a display board (panel) and a table bench. The bench provides for the siting of hardware and samples. The sponsor's 'brief' should include these items together with overall dimensions and weights. If the designer is in possession of these details, he can design the whole unit to appear intentional and not as a display board with bits and pieces dumped on afterwards! There is a weight limit but this can be overcome by the strengthening of the bench. An additional ground level platform can be incorporated with the 'unit'.

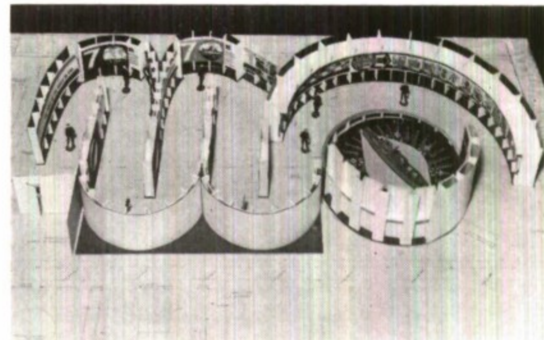
Small sized pieces of equipment can be fixed to the display board and again incorporated within the design of the display. Special features may be shown by adapting the display board and again incorporated within the design of the display. Special features may be shown by adapting the display board to include them. Transparencies can be shown by using purpose made light boxes; back projection and oscilloscope screen can also be incorporated in displays.

Supplementary Displays

This type of display is normally sited in a workshop or laboratory where large equipment and installations are open to the visitor. They are wall mounted display boards and provide informaton relevant to the specialisation of the department. (The 'Standard Unit' may also be used where space permits). Some departments, wishing to display a purpose built rig or operational sequence for 'Open Days' can employ the 'Supplementary Display' which can be fixed to the wall behind the demonstration.

The Central Exhibition Display

The 'Display Plan' referred to in Part I takes account of the central exhibition feature. This should normally apply where the establishment is large and extensive. The purpose of this type of presentation is to put the establishment under one roof and provide the visitor with a comprehensive story of the functions and developments. This should not prohibit him from visiting a particular department, which may be situated at some distance from the central exhibition. The central exhibition can be considered as the display windows of a large departmental store, where the customer can see the merchandise at a glance and then enter and visit the particular department of choice.



A model of the proposed central exhibition display for the forthcoming ASWE Open Days.

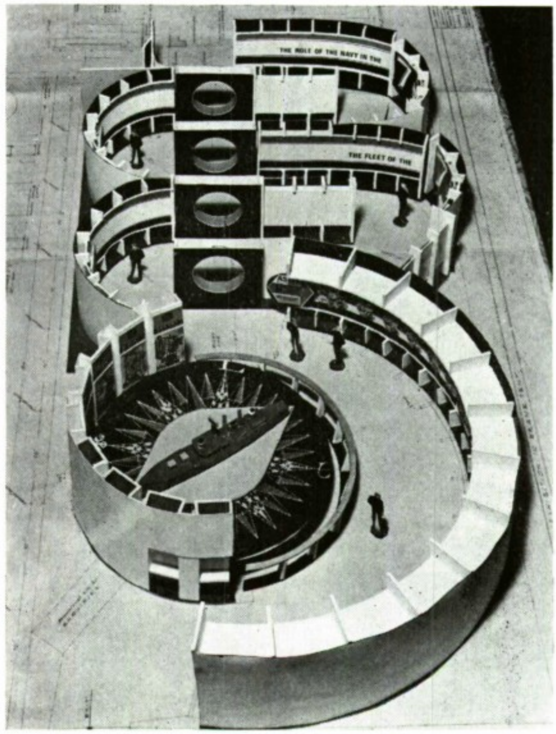
According to the space available, the central site can be made to accommodate cloakrooms, reception area, lounge and cinema (if required) together with the information displays. This arrangement creates a good first impression and should whet the appetite of the visitor who may anticipate the 'courses' to follow. The visual aspect provides a better scope for the designer to develop the 'impresson' theme. The 'Steering Committee' must provide a comprehensive specificaton of their requirements at an early stage, similar to the 'schedule of exhibits'. Some establishments may not be fortunate in having suitable space within permanent buildings for such an exhibition. If suitable outdoor space is available—sports ground, tennis court, grassed area, paved or surfaced area, allowing a minimum site measurement of 50ft. × 70ft. —the use of a frame tent can be considered. This type of structure has been successfully used at some research establishments. The tent, which differs from a marquee by the use of stout framing and roof trusses, can be hired from a recommended contractor.

The central reception exhibition at AEW Open Days.

If an establishment has a particular theme for the 'Open Day' the central exhibition provides the best opportunity for getting it across to the visitor. In the case of anniversary occasions, the historical background could provide the material for an introductory display, which can show the progressive developments up to the present time.

From a practical standpoint, the central exhibition should provide for better production control as compared with the divergent requirements of laboratory displays. Finance is the all important factor for all forms of 'Open Days' and where an establishment wishes to preserve their investment in the display material produced and would prefer to stage a central exhibition, they may do so by placing laboratory displays in a central area, allowing the laboratories to 'speak for themselves' when the visitor calls. This enables the visitor to concentrate on the particular work of the department without the additional attention needed to examine displays. There are departments who would prefer this situation either, because of possible disturbance to sensitive equipment (where a display stand would not be practical) or, they are only interested in the 'specialist' visitor and prefer to discuss details with him.

A representative central exhibition also satisfies a visitor who has a limited amount of time and cannot visit the departments of an extensive establishment. At least he will not leave without obtaining a comprehensive picture of the work done in the establishment. The weather can also affect the viewing opportunities—especially rain—and the central exhibition can offset this disadvantage.



A proposed model layout for an exhibition.

Summary of Procedure

1. Steering Committee produce 'schedule of exhibits' based on department suggestions or positive requirements.
2. Co-ordinator appointed and 'Vetting Committee' formed.
3. 'Production Unit' formed and working facilities arranged. Control schedule drafted.
4. Sponsors (department requiring displays) submit 'brief' of this requirement: title, sub-title (if any), text, photographs, drawings, captions and articles to be displayed.
5. 'Vetting Committee' pass approved 'brief' to designer.
6. Designer consults sponsor (where possible) and prepares layout drawing—setting out sizes, positions, lettering articles and colour: special material specification.
7. Sponsor approves layout and passes to co-ordinator who puts the work in hand with the production unit and workshops.
8. The completed display is stored in readiness for the 'Open Day'.

General Summary

The success of an 'Open Day' depends on good organisation throughout the particular establishment, and the maintenance of good communications during the preparation period. Communication and information at all stages of production, should be maintained. Failure in this respect will lead to chaos as the 'Open Day' approaches.

The design team will always appreciate a complete 'brief'; they are then able to produce a result which looks intended. Unfortunately cases have been known where half the story has been provided and the other half revealed two days before the opening date !

Firm control should be exercised over priorities; failure in this respect can upset planning and ultimately lead to disorder in the final stages.

Representatives of workshops, photographers, production unit and Drawing Office should be present at progress meetings to ensure a true overall state of progress.

When the services of M.T.I.P.(N) Design Section are employed they will always endeavour to assist in every possible way, within the terms of their duties. In return, the Design Section expects the particular establishment to respect their knowledge and experience and to foster a trusting relationship. Exhibition design and display is the specialised work of the Design Section and they in turn appreciate the non-specialist's (Sponsors) reaction to the demands of exhibition work, which can mystify and perplex. The designer will not interfere with the complexities of scientific research but he will do his best to express the subject in graphical terms, and ensure that nothing is overlooked but will be dealt with in its respective production place.

The resulting appearance of exhibitions and displays is deceptive, when one considers the amount of effort required to produce a simple result or, to make the point—actively engages in production to appreciate the amount of effort required. This output and effort poses the question, 'Is it worth the effort ?' If a good result is achieved it is worth the effort—if the result is bad the effort should not have been made. Mention has been made in the first article regarding the present day requirements of 'Open Days' to consider the commercial usage of research facilities. This surely calls for good presentation to 'sell' the facilities and justifies the effort to achieve this. The display material produced will provide a dividend for the establishment; to be used for visitors and for those occasions when the department receives a request for displays to represent their activities at other exhibitions.

The author hopes these articles will be of some use to those contemplating 'Open Days' and may help to prepare the ground where establishments are considering the services of M.T.I.P.(N).

I.E.E. COMMEMORATIVE PRIZE

Applications are invited for the 1971 award of the Karl Heinz Gyr and Heinrich Landis Commemorative Prize. This prize, of annual value £250, is administered by the Council of the Institution of Electrical Engineers at the request of the donors, Messrs. Landis and Gyr, and has been instituted by them to commemorate the work of two notable pioneers in the field of electrical measurement.

The prize will be awarded for a meritorious contribution to the advancement of electrical or electronic science or engineering which, in the opinion of a panel of adjudicators appointed by the Council, represents an outstanding achievement.

While the whole field of electrical and electronic engineering may be reviewed, the adjudicators will have regard to the donors' wishes that, where merit is equal, advances in the science, art and practice of electrical measurement will take precedence.

Applications for the first disposal of the award, to be received not later than 15th March, 1971, should be sent to the Secretary, the Institution of Electrical Engineers, Savoy Place, London WC2R 0BL, on Form GLCP, copies of which may be obtained from him on request.

AEL GOLDEN JUBILEE OPEN DAYS

The Admiralty Engineering Laboratory opened its doors for a week in July. VIPs, Press, visitors and families all had an opportunity to see how AEL helps to keep the Navy operational. The occasion was one of celebration, marking the Golden Jubilee of the Establishment at West Drayton.

During the five days on which the Establishment was open some 2,500 visitors toured the exhibits and showed great interest in the work of the Laboratory. A marquee was erected on the tennis court as a reception centre. Here a display of photographs gave the visitor a cross section of the Laboratory's activities and of its history, enabling him to pick out items of special interest. Lunch was provided in another marquee on the Cricket pitch. Apart from a downpour on the VIP day the whole proceedings went very smoothly and, judging by the visitors' comments and letters of congratulation, a great time was had by all.

The success of this occasion and the high quality of the displays were due very largely to the help and unstinting efforts of NSTIC, MTIP and OS (SR). Much valuable guidance was also obtained from other Laboratories such as NCRE which had its own Open Days in 1969.

Mechanical Department

The work of the Mechanical Department at AEL is directed towards improving the reliability and the suitability in all respects of the Navy's diesel engines and certain other machinery. Thus the exhibits comprised items such as the evaluation of engines for eventual adaptation for Naval use, automatic control devices for engines, methods for reducing wear and corrosion, and techniques for minimising the energy transmitted from machinery to a ship's hull either as airborne noise or structure borne vibration.

Engines and Metallurgy

A number of diesel engines from 10 to 2000 hp were shown under test conditions, most of them housed in individual soundproofed test cells in which they can be run unattended, fully instrumented and monitored by automatic shut down devices. A 6 LTS $9\frac{3}{4}$ in. bore turbo-supercharged 6-cylinder engine was shown operating with a set of oil-cushioned pistons. Such pistons, developed at AEL from original work at ARL, improve lubrication and fuel consumption and reduce wear. Vibration is also lessened, with a consequent reduction of piston-slap noise, and less damage to wet liners from cavitation erosion.

All the useful power developed by an engine is conveyed by the crankshaft(s), which must therefore be capable of standing up to the considerable stresses involved and yet be as economical as possible in size and weight. Thus two test rigs were demonstrated for the fatigue testing of full scale crankshafts in bending and torsion respectively. These are the largest known rigs employing the slipping clutch method of excitation, and are available to industry as an occasional revenue earner for the Laboratory. Also shown was instrumentation set up for the measurement of strain on a large end bearing block of an Admiralty Standard Range 2000 hp submarine engine, under full operating conditions.

Other instrumentation for the dynamic and static stress analysis of crankshafts was shown, results from which had determined the design of non-magnetic crankshafts for an 18-cylinder Ruston-Paxman Deltic engine, shown running under full power. It is intended to power the non-magnetic G.R.P.-hulled mine counter-measures vessel, now being designed, with a non-magnetic Deltic engine.

Recirculating diesel engine cooling water necessitates chemical treatment to reduce

PERSONALITIES OF ADMIRALTY EXPERIMENTAL LABORATORY

Back row, left to right: Captain T. W. E. Dommett (Superintendent 1960/1962); Mr. R. J. B. Keig (Chief Scientist—retired 1966); Mr. L. Neighbour, Head Messenger (1920 ——); Captain S. A. Harrison-Smith (Superintendent 1948/1950); Captain W. G. Pulvertaft (Superintendent 1950/1953); Captain P. H. Craven-Phillips (Superintendent 1956/1960).

Front row, left to right: Mr. F. R. W. K. Mansell (present Head, Electrical Department); Mr. H. C. Fitzer (present Director of Engineering (Ships)); Mr. G. B. Fox (Deputy Superintendent—retired 1950); Vice Admiral R. G. Raper (present Director General Ships); Acting Captain C. M. Hall (Superintendent 1942/1943); Captain N. J. H. D'Arcy (Superintendent 1947/1948); Captain W. A. Humphrey (present Superintendent, from 1968).

corrosion of the metal surfaces contacted, but full scale engine trials are expensive. A test rig developed by AEL in collaboration with other interested organisations was shown in operation, in which all conditions can be simulated, that is to say, relative areas of materials, temperatures, pressures, and air content, together with test 'coupons' of the metal under observation.

Hydraulics

Means for evaluating filters for lubrication and hydraulic systems were shown, together with the Coulter particle counter previously described in this journal. One hydraulics problem is the sealing of propeller shaft stern glands against the ingress of water, this having become of special significance with the advent of deep-diving nuclear submarines. The mechanical design of such seals is much more complex than is generally realised. A test was shown in progress of the improved sealing, against a controlled water pressure, effected by using chrome oxide as coating for the static ring of a shaft seal, with babbitt-loaded carbon as the rotating ring of the seal.

Machinery Controls

Control of an engine using fluid logic was demonstrated on a Paxman Ventura 500 kW generator set. This system, operating on compressed air, automatically checks significant fluid levels, pressures, and temperatures, both preparatory to starting and continuously

Mr. Albert Duberley, Head of Machinery Control Section, explaining the A.E.L. Roll Stabiliser Control System to the Controller, Vice Admiral Sir Michael Pollock, Mr. B. W. Lythall, Chief Scientist, Royal Navy, looks on with interest.

In the right hand group Mr. L. Williams, Apprentice Training and Mr. W. Harper, Deputy Works Manager, discuss training problems with Mr. K. Taylor, of S.S.P.(N).

during running, with a fault-operated shutdown. This system is installed in H.M.S. *Bristol* and is specified for the Type 42 frigate.

Applications of computers were shown; problems that have been evaluated include those of boiler control, oxygen generating plant control, and ships stabilisation. The Section's facilities comprise two EAL TR10 (analogue) and two EAL TR48 (hybrid) computers. Ships stabilisation was demonstrated on an elegant 4 ft. model of a LEANDER-class frigate, especially made by the Establishment's carpenter. Visitors were able to switch on the simulated stabilisation control and thus reduce a disquieting plus-or-minus 10° roll of the model vessel to a figure about one-tenth of that amount. Alas for those prone to sea-sickness, no such control has been established over pitching motion! The AEL system relies solely on the measurement of roll angle, from which velocity and acceleration are derived. Solid state electronics are used. The system has been adopted as the standard equipment for future Naval ships including the Type 42 frigate.

Of considerable interest to all ship operators was a compact electronic system developed at AEL giving a digital display of propeller shaft revolutions per minute, torque, and thrust, together with paper recordings if so required.

Noise and Vibration

In many instances it is operationally essential to minimise the transmission of machinery vibration to the hull of a ship, and to do so effectively the relevant mechanical parameters of machine, supports and hull must be known. The AEL equipment, of which the original has been described in this Journal, for automatically measuring mechanical impedance (the complex ratio of applied oscillating force at a point to the velocity produced) over a frequency range, was shown in operation. The isolation obtained by a vibration-damped seating was illustrated by a floating test-bed model in a water tank, and a computer-assisted design of a vibration-damped seating was shown supporting a Foden diesel generator unit. One characteristic of high-efficiency Diesel engines is the intense noise radiated from them, hence this Foden unit was shown fitted with Acoustic Cladding of the type developed by AEL; visitors were thus able to form a subjective judgement of the improvement affected.

Because of the vast volume of data acquired during AEL ship trials of noise and vibration, a sophisticated high speed data analyser embodying an Elliott 903 computer is due to be in service at AEL in 1971; a preview of this was displayed. For more routine checks on vibration, for example as a maintenance aid, an instrument was shown in which existing

vibration levels on a machine could be readily compared with reference or tolerated levels established on a punched card.

Certain exhibits not shown on Open Days were displayed afterwards during the visit of the Controller and the Chief Scientist of the Navy.

Those who sought general lessons from these Open Days may have discovered two in particular. The first, that no Section or even Department can be viable without considerable interaction with other Sections and Departments. The second, that there is now so much electronics involved in solving mechanical problems that it is essential for the mechanical engineer to become fully acquainted with its possibilities and usage.

Electrical Department

Work in the Electrical Department is directed to research, development and evaluation over a wide range of electrical and electronic equipment for use in the Fleet. Only the briefest details of a selection from the many exhibits will be given but further information may be obtained on request.

Control Systems

One-man control of a submarine was featured in the Drayton Submarine Position System which gives present and future positional data on an oscilloscope and allows a relatively unskilled operator to carry out Depth-Course manoeuvres easily. Visitors were allowed to test their skill on the Deck Landing Projector Sight mounted on a rolling platform. This provides a lamp display giving landing information to pilots of modern high-speed fixed wing aircraft and is stabilised against the pitching motion of a carrier. A detailed model of the equipment made in the section has been on display in the House of Commons. Another interesting item was the Programme Read-out Unit giving a direct display of course-to-steer information to the Officer of the Watch when zig-zag steering patterns are being executed.

Electronics and Nucleonics

A novel type of Statie Rectification and Inversion system was demonstrated which offers many advantages over conventional methods. In the three phase ac - dc mode, using diodes, harmonic distortion in the ac supply is considerably reduced, and in the reciprocal mode three-phase ac power over a range of frequencies is produced at high efficiency with good sine wave shape by the use of silicon controlled rectifiers. Solid-state starting of three phase electric motors was featured in the new type of starter developed in the section. A wide range of nucleonic health monitors and other equipment was on show in the separate Nucleonic Laboratory.

Machinery

Supply systems investigations were demonstrated and an AEL solution to a recent serious failure in ships' motor generator sets was shown. Considerable work on reduction of noise and vibration in electrical machinery has been carried out and has led to the concept of monitoring machines for early failure detection.

Thermal protection of electrical machinery with electronic trip-out is being evaluated; one interesting development item was the carbon-fibre brush which shows some promise.

Switchgear

The ever increasing powers in use and the increasing need for absolute reliability of supplies has caused ever rising standards of performance to be demanded from ships' switchgear. The investigations of the section and manufacturers' co-operation have resulted in many improvements and examples of all types of switchgear and contactors were effectively demonstrated. Solid state starters are currently being evaluated and a large range of devices such as magnetic reed switches and other switching devices undergoing test were shown. Visitors to the section were also able to see the largest lead-acid battery in the Western Hemisphere which has given 125,000A at 220V.

Shock and Vibration

Many visitors were to be seen with their fingers in their ears during the firing of the two-ton shock test machine and emerging from the building visibly shaken by the demonstration of the forces involved. AEL initiated and developed the first shock test machines in RN service and the design developed by the late Mr. Duckworth is only now being superseded after almost 30 years.

Batteries and Cables

The very large machine for testing strain cables of all types under tension of up to 10

tons proved an attraction for visitors as also did the unique facilities in the cable test laboratory. The large submarine cells on test in the Battery Test Bay with the facilities for charging intrigued others, whilst most people were impressed at the sight of silicon cables glowing at white heat from fierce jets of burning gas and still maintaining insulation resistance. A very large range of batteries for use in air-sea emergencies was shown, also an accurate stibine gas detection method.

Telecommunications

In addition to new methods of time-shared communication channels for ships' telephone systems, a demonstration which surprised many visitors with the fidelity of voice transmission, visitors could enter the anechoic room and experience the uncanny feeling of a noiseless (relatively) world. This section pioneered electronic flight deck communication using a magnetic loop and an impression of its effectiveness in extremely noisy surroundings could be gained. Another facet of the section's activities was given in a film showing how the Magnetic Range at Ditton Park, Slough, is used to evaluate equipment in magnetic tests and the new positional indicator for the test trolley on its track explained. The film made at AEL by the Photographic Section, and provided with a commentary, was a most professional and polished production. A paper is to be published including details on the position indicator system called METRAC in which each position of the test trolley on its track is uniquely defined by digital code signals received via pick up coils without physical contact.

Museum A special museum was open showing a large number of exhibits from 1875 onwards and covering the electrical machinery, lighting, telecommunication, and measurement fields. It will be the subject of a short article later. Many visitors turned green with envy at the display of silverware from the Royal Yacht *Victoria and Albert*.

The President of the Institution of Electrical Engineers was escorted round many of the exhibits mentioned and his comments were very favourable both on the exhibition and the standard of research and development.

Letter to the Editor

Dear Sir,

Referring to the article on TIME in the January 1970 issue of the *Journal of the R.N.S.S.* (Vol. 25 No. 1) a statement is made that no one yet has been able to give a completely satisfactory definition of time. While this may be true there are some axioms stated by L. Ron Hubbard in " Fundamentals of Thought " which place time in a workable perspective. They are related to time and space and are thus:

(a) Space is a viewpoint of dimension.

(b) Time is basically a postulate that space and particles will persist.

(c) The apparency of time is the change of position of particles in space.

(d) Change is the primary manifestation of time.

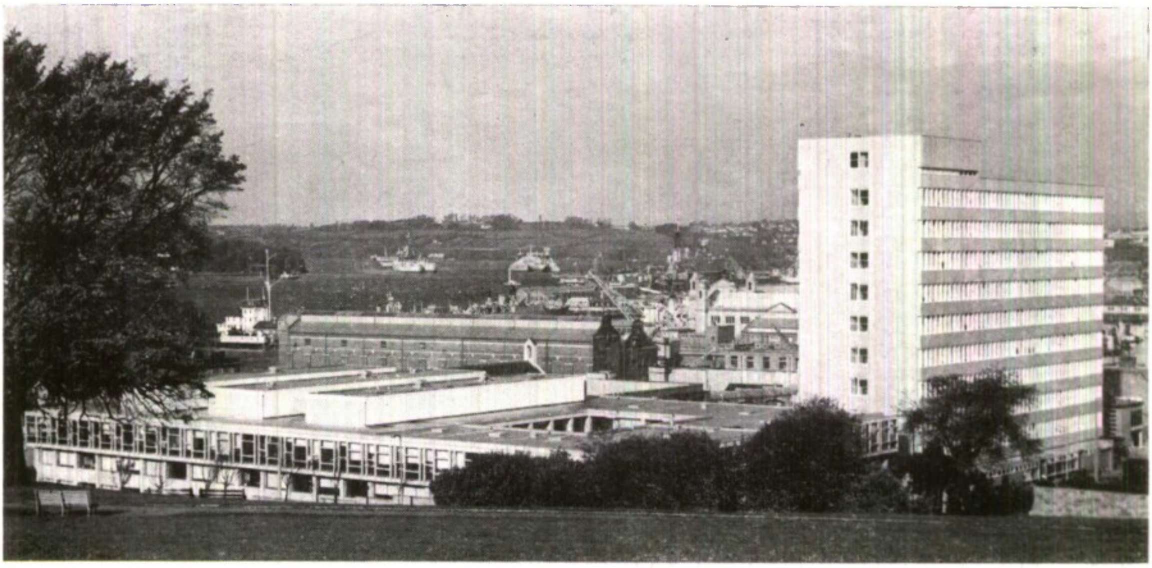
I hope that the above may be of interest to readers who are interested in this fascinating subject—time.

Yours faithfully,

P. Huffam

Lieutenant Commander, R.N.Z.N.,
Weapon and Electrical
Engineer Officer.

H.M. DOCKYARD, DEVONPORT



Showing new Central Office Block (right) in North Yard. Flagstaff steps left (framed by tree). View of combined Design Division along foreground (seen from Devonport Park).

In view of the new plans for the dockyard at Devonport which have been announced, the following historical note describing its development since 1691 is of interest.

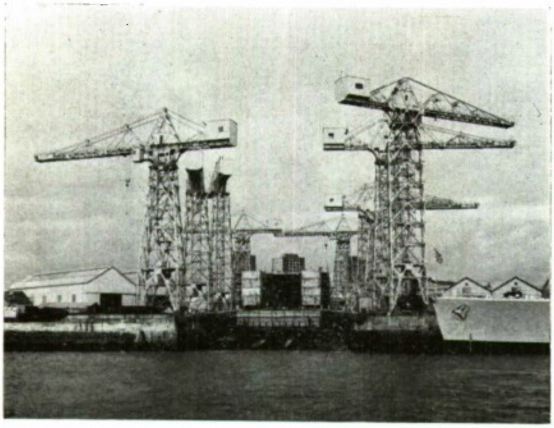
The Dockyard had its origin in threats of war and invasion from overseas. In the 17th century, the Dutch made a number of daring raids on East coast ports and demonstrated that the existing Dockyards clustered around London could not guarantee safe berthing for the Fleet. Coupled with this, the French had established a Naval base at Brest from where they could make lightning raids on English shipping in the Western Approaches. Plymouth had been used as a Naval port by Drake, Raleigh and Hawkins in the reign of Elizabeth I, but William III chose it for a dockyard.

After various sites were surveyed in Plymouth and elsewhere, the place eventually chosen for the new Dockyard was Froward Point in the Hamoaze and an estimate was accepted in 1691 to construct a wet and dry dock (the latter leading off the former) for the sum of £11,008. This work was completed in 1692 and by 1697 a compact little yard of 24 acres had been established which included residences (which were also used as their offices) for the Commissioner and his 10 Senior Officers, workshops and a Ropery nearly a quarter of a mile long.

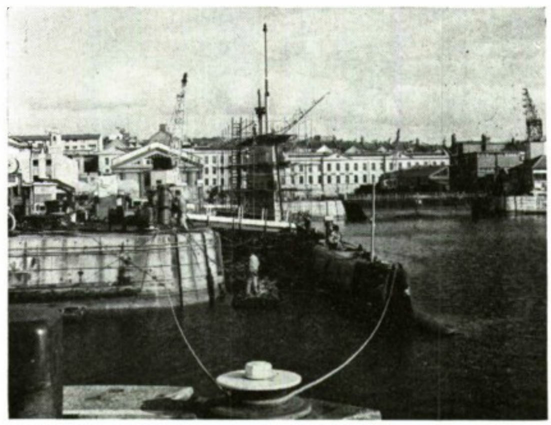
The number of workmen employed in those days was 74 and they were accommodated in ships afloat but, as the labour force grew, houses were built immediately to the North of the

Dockyard wall from 1700. This effectively prevented the expansion of the Dockyard northwards, but it did expand to the South by acquiring what was known as " new ground " on the South side of the Camber.

The Dockyard now had four docks, the last one being completed in 1789. George III paid it a visit in that year and was told that it had been built larger than was necessary to take his biggest warship. The officers waited hopefully for their Royal Visitor to ask why and they were not disappointed. They explained that, during the course of building, they had received news that the French were secretly building larger ships than the English and the dock had therefore been increased in size so that, should one of these ships be captured, it could be docked and repaired. The cool cheek of the West Country planners paid off for the largest of the French ships the 120-gun *Commerce de Marseilles,* was captured and became the very first ship to enter the new dock.



SOUTH YARD Building Slip.
Many ships including Dreadnoughts "Ocean" and "Queen" and modern frigates "Plymouth" and "Danae" were built here.



NORTH YARD
Submarine in No. 2 basin.
Old Central Office Block in background (Victorian) and caisson to a dry dock to the right of submarine.

Steam was introduced into Naval ships early in the 19th century but the Admiralty did not trust it and many vessels had both steam and sail. By the middle of the century the demands of the engineers could no longer be ignored and the Admiralty decided to establish Steam Yards at Portsmouth, Devonport and Malta. The site chosen was at Keyham to the north of the Army Ordnance Depot. Three docks and two basins were constructed as well as the necessary foundries, machine shops, rigging houses, workshops, offices and stores. All the buildings were grouped together into what is known as the Factory. This is a block about 750 ft. by 600 ft. and covers an area of 10 acres. It stands much the same to look at as when it was opened in 1853 solid and immovable as the Rock of Gibraltar and creating impossible problems for modern motor traffic around the Dockyard.

The two parts of the Dockyard were separated by half a mile and in 1856 a tunnel was excavated to join them. At first it was used by horse and cart, but eventually a railway was built which carried both passengers and goods to all parts of the Dockyard.

Expansion from the beginning of the 20th century was rapid and, after ten years work, the great Extension Yard was completed by Sir John Jackson and opened by the Prince and Princess of Wales (later George V and Queen Mary) in 1907. This consisted of the huge Prince of Wales basin and four docks which have since been extended to take the largest of our present day Aircraft Carriers. In 1939 the Army moved out of the Ordnance Depot which had been built in 1725 by Sir John Vanburgh,

Architect to the Ordnance, and the Dockyard moved in. This has now become Morice Yard and is used for the repair and maintenance of tugs and small craft as well as for storage. In 1950, the Dockyard wall marched out to engulf an area of bomb-damaged Devonport and in 1956 the requirements of the Electrical Department (very much the junior partner since it was formed in 1903) were met by the construction of the Electrical Engineering Factory in Goschen Yard which is sited inland from the Steam Extension Yard. In 1963, the dream was realised of making the whole into a single Dockyard by means of constructing fly-over bridges from the old South Yard into Morice Yard and from there into the Steam Yard (now known as North Yard) so that all parts of the Yard can be reached without going outside the Dockyard wall.

Devonport Dockyard is now the largest ship-repair Yard (Naval or private) in the country. It has 15,000 employees and covers nearly 400 acres, spread over two miles of water-front. It has 12 dry-docks which are constantly in use and about two dozen ships are always under repair. Government decisions announced last year ensure a prosperous future. These include the repair of nuclear submarines and the use of covered docks to refit the LEANDER class frigates on a production line basis. All this will not be achieved without a change in the Dockyard image. The Management structure has already been re-organised on modern business lines and productivity agreements are being negotiated with the workpeople. The Dockyard hopes to continue to be the mainstay of Plymouth's economy as it has been for the last 200 odd years.

THE INTERNATIONAL ELECTROTECHNICAL COMMISSION

Every year about 2,000 people, mainly electrical engineers, spend some days as delegates to international meetings of one or more of the 400 Technical Committees, Sub-Committees and Preliminary Working Groups of the International Electrotechnical Commission (I.E.C.).

Backing up these delegates to I.E.C. international committee meetings are a much larger number of those who, in meetings of electrotechnical committees in their own countries, discuss their own and other countries' comments on I.E.C. draft Recommendations for international electrical standardization, brief their delegates to the international meetings, receive their reports and, on receipt of a final draft, put forward a vote from their I.E.C. National Committee as to whether this draft is acceptable to them.

International Understanding

The I.E.C. exists to promote the harmonization and, where possible, the unification of national electrotechnical standards.

One of its first aims is to improve understanding between electrical engineers of all countries by agreeing common definitions of electrical terms. For instance, the Second Edition of the I.E.C's International Electrotechnical Vocabulary (I.E.V.) comprises nearly 9,000 electrical terms in eight languages—nearly 70,000 altogether—with explanatory definitions of each in English and French. Individual I.E.C. Technical Committees also find the need for definitions when they are drafting or discussing their Committee's proposals for international standardization.

Electrical Science Universal

Electrical engineers have a great advantage in that the same scientific laws relating to electricity are expressed in the same terms of measurement in any country—the volt, the ampere, the ohm and many others. Their scientifically international basis is shown by the naming of them to commemorate physicists in the pioneer days of electrical discovery—Volta, an Italian, Ampere, a Frenchman, Ohm, a German. Other electrical units also bear the names of internationally recognized scientists.

The I.E.C. went 'metric' years ago by adopting the MKS basis of measurements (metre, kilogram and second) in its international system of units and quantities—the groundwork for the present S.I. units (Système International).

International trade in electrical products is, of course, still subject to some of the problems of description in different languages, of different trading terms and of different currency units, but common agreement on technical terms and units of measurement is a considerable help.

Standard Specifications

The I.E.C. goes, however. much farther than this first step of common scientific and technical definitions. Its Technical Committees, each in its own field, recommend specifications for electrical products based on world wide expertise and on the consolidated results of world-wide technology.

National standards exist in many countries for a very large number of electrical products, from components to sub-assemblies, from

assemblies to functioning units and from apparatus to equipments and installations.

Manufacturers want the benefit of quantity production without too many variants. Purchasers want reliable and safe performance and when tenders are invited, they want to know whether offers are on a comparable basis.

It has been one of the main tasks of the I.E.C. to lift some of the burden of trading across National boundaries.

Electrical Trading

Trade between different countries in electrical products has been increasing very rapidly — more rapidly than world trade in general. Such trade, expressed on a basis of U.S. dollars, amounted to about 4,000 million dollars in 1960 and in 1970 about 15,000 million dollars.

The highly industrialized countries have seen that their electrical exports are conditioned by the standards of other such countries. The less developed countries have seen that their electrical needs can be met by purchasers from different countries—and they want to know whether offers are on a comparable and a reliable basis.

Gradually, over the last ten years, electrical specifications have become more international. It is becoming much more usual for the first draft of a new and revised national electrical specification to be that already hammered out internationally by an I.E.C. Technical Committee.

Practical Limitations

It is true that a particular country may not be able to accept an I.E.C. international Recommendation as a whole without some reservation, but such variation are becoming less significant each year.

Of course, there are some few well-established electrical products where different countries have in the past adopted standards which it would need too great an upheaval to readily reconcile with the standards of some other countries. There are, for instance, millions of British domestic plugs and sockets in use which are not interchangeable with those of other countries—but which have their own advantages.

It is very difficult to change established practice—even in the comparatively new electrical industry. But electrical experts all over the world have now learnt that standardization can come too late—but hardly too early.

Dimensions and Functions

Dimensional standardization has been achieved in many of the simpler electrical components. Indeed, in electronic components standards have been international almost since their inception. Such standardized component dimensions and standardized unit specifications are an assistance to the designers of more complex equipment. But as the equipment becomes more complex, the emphasis on dimensional standardization diminishes and the emphasis on standards of performance, safety and reliability increases.

Test Specification

In the drafting of Recommendations for standard specifications it is usually necessary to introduce test clauses by which the criteria specified for different aspects of performance, safety and reliability can be checked.

It is not always easy to specify tests which will give comparable results on different products in different testing stations. It is also not easy to specify tests which, when performed in a laboratory, will give results relevant to performance under practical working conditions over a long period of service.

Trouble-shooting experience can lead to investigations which often promote research into the causes of failure, to improvements in design —and to the revision of test requirements. The basis of standard tests is a technical problem to which both suppliers and ultimate users can contribute in international discussion to their mutual benefit.

When the ultimate user is the general public the task of measuring performance by standard tests may bring in questions of what kind of performance is expected. Even in devising Standard Methods of Measuring Performance (S.M.M.P.) differences in national habits can suggest different tests. Also, safety evaluation must work on the basis of clearly defined limiting values to be obtained as the result of standardized test methods.

Delegates to meetings of I.E.C. Technical Committees dealing with electrical appliances sold to the public have problems which differ from those of Committees dealing with products sold to engineering and technical buyers.

Electrical Products

As there are over 60 I.E.C. Technical Committees, apart from their Sub-Committees and Working Groups, a long list of even their titles would be required to indicate the wide range of electrical and electronic techniques which they cover in considerable depth. Their subject-matters are also crosslinked, as for instance, between components, assemblies and equipments.

The I.E.C. Technical Committees can be grouped in several ways of which the following grouping is an example:—

(1) Committees concerned with electrical terminology, units, symbols, standard ranges, standard test methods, etc.

(2) Committees concerned with materials important in electrical practice—copper, aluminium, solid, liquid and gaseous insulators, magnetic materials, crystals, etc.

(3) Committees mainly concerned with equipment used in power generation, transmission and the use of electric power in industry.

(4) Committees mainly concerned with the smaller items of electrical installation—instruments, relays, fans, batteries, lamps, fuses, appliances and accessories.

(5) Committees mainly concerned with electronic components and assemblies used in radio, television, telecommunications and in industrial controls and systems.

(6) Committees mainly concerned with the performance, safety and reliability of applications of electric power and control in different kinds of installation—in buildings, in ships, in electric traction, in mines, in machine tools, in hospitals, in process control and in the special use of electricity in welding, heating, refrigeration, air-conditioning.

Delegates Experience

No-one can hope to be equally expert or experienced in more than a few of the above subjects. A balanced consensus of opinion has also to be obtained from representatives of manufacturers and users, of electricity supply authorities, of governmental corporations and departments, of Universities and Technical Colleges, of electrical trade associations and of the staffs of National Standards Institutions.

Those who attend either national of international meetings concerned with the drafting or discussion of electrical standards have much to learn from each other. They have to accept the fact that other people and other countries can have good reasons why they differ in their ideas on technique and standardization. Research into the technical basis on differences has often resulted in bringing out relevant facts that had not previously been fully considered. The more the differences, the longer it may take to arrive at an agreed standard—but the more worthwhile. Occasionally progress seems very slow, particularly in harmonizing techniques that have been long-established. On the other hand, when newer techniques are introduced, delegates to international meetings sometimes find themselves being overtaken in knowledge and experience.

Standards

An analysis of the I.E.C.'s Annual Catalogue of current Recommendations shows that about 50% of them are either first or revised editions published in the last three years or updated in that time by the issue of amendments and supplements.

Research and development in the electrical industries has been so rapid and extensive in the post war years that electrical (and electronic) standards have to be revised and expanded even faster than the increases in electrical production and in electrical and international trade.

Thus the I.E.C. Technical Committees have to take into account:—

(1) The revision of existing recommendations because of new materials—for example, new insulators used in rotating machines.

(2) The extension of I.E.C. Recommendations to newer technologies—for example, nuclear instrumentation, microelectronics, etc.

(3) The extension of existing specifications to cover factors not previously fully standardized—for example, test procedures and protection for different installation conditions.

(4) The extension of I.E.C. work in fields where only national and regional standardization has so far been applied—for example, many household electrical appliances.

(5) The extension of I.E.C. Recommendations to products where the numbers it is possible to sell can only repay the high cost of their development if the same design can be sold in a number of countries without serious modification to suit National regulations—for example, electric and electronic equipment for medical practice.

Grouped Meetings

There is hardly a week in the year in which some international I.E.C. meetings (of Technical Committees, Sub-Committees or Working Groups) are not taking place somewhere. There are about 40 I.E.C. National Committees, each with their own sub-divisions of electrical interests. The issue of drafts, comments from National Committees, reports and administrative circulars to all of them in the numbers requested to advise the members of their relevant committees means a large daily and world-wide circulation of papers from the I.E.C. Central Office in Geneva.

For the convenience of delegates and of those countries which are most limited in the numbers of competent delegates they can send to international meetings, the I.E.C. Central Office, with the help of the Technical Committee Secretariats, tries to group meetings of several Technical Committees into the same location and time—not always easy as Technical Committees on related subjects may not be ready at the same time to hold an international meeting.

General Meetings

Once a year, however, by the invitation of a National Committee, a large number (perhaps a third) of the I.E.C. Technical Commitees can be planned long beforehand to meet in the same location at the same time or at least during the same fortnight.

Annual General Meetings in the last 15 years have been held in London, Munich, Moscow, Stockholm, Madrid, Delhi, Interlaken, Bucarest, Venice, Aix-le-Bains, Tokyo, Tel-Aviv, Prague and Teheran. The 1970 Annual General Meeting in Washington is the first held in the U.S.A. since the "Jubilee" meeting in Philadelphia in 1954 that celebrated the St. Louis Congress in 1904 which led to the formation of the I.E.C. in 1906 with Lord Kelvin as its first President.

The I.E.C. Annual General Meeting is not only an occasion which provides exceptional publicity to the work of the I.E.C. in the "host" country. It also gives more of those who take part in I.E.C. work in that country an opportunity of seeing the international aspects at first hand.

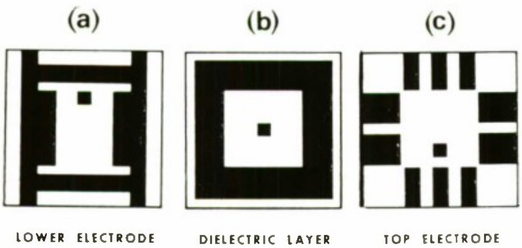
The "host" National Committee also arranges a number of technical visits of interest to delegates and also several social occasions when delegates to different committees can meet informally. The chief members of National delegations also meet in Council and Council Committees to discuss current problems — including the approval of any new committees or modifications of the scope of existing Technical Committees—an important point in the I.E.C. organization in which the subject matters of different Technical Committees are carefully interlinked.

The work of the I.E.C. expands each year to match the growing variety of electrotechnical products sold and bought throughout the world.

TECHNICAL NOTES

Screen Printed Thick Film Capacitors

The screen printing of capacitor dielectrics marks a significant step forward in thick film technology. It has now been shown that capacitors can be screen printed to give capacitances of up to 80,000 pF/in² (12,500 pF/cm²), voltage breakdown in excess of 500 V, and insulation resistance in excess of $10^{12}\Omega/\text{in}^2$ ($155\times10^{9}\Omega/\text{cm}^2$).



CAPACITOR TEST PATTERN

The test patterns were used to construct capacitors in an experimental assessment of barium titanate based dielectric. Sequential printing through 165 mesh screens, made from these patterns, produced 10 capacitors having one electrode common. The lower electrode, of platinum-gold paste, was printed first using screen (a). This was dried in air for 20 minutes at room temperature before being fired at 950°C. The dielectric layer was then printed from (b) using Dupont EP 8229 paste and allowed to dry at room temperature followed by further drying at 140°C.

In several of the test batches a further dielectric layer was printed in the same manner to ensure that pinhole defects in the first layer were covered by the second layer. The upper electrode (c) was then printed using platinum-gold paste and allowed to dry before co-firing all three layers at temperatures of 750°C, 800°C or 950°C. Variations to the procedure (other than temperature) included single or double dielectric layers, fired separately or together with the upper electrode. The results achieved show that capacitors can be manufactured at a high yield rate using this process in any of the variations described.

Although capacitors can be fired at the same temperature as thick film resistors co-firing of these two circuit components has not been found practicable due to random increases in resistor values which occurred during this assessment. It is recommended that, for circuits containing these two components, the capacitor is made in the manner described and fired at 800°C before printing and firing the resistive layers at 750°C.

Hydrostatic Pressure Measurement using Piezo-Electric Transducers

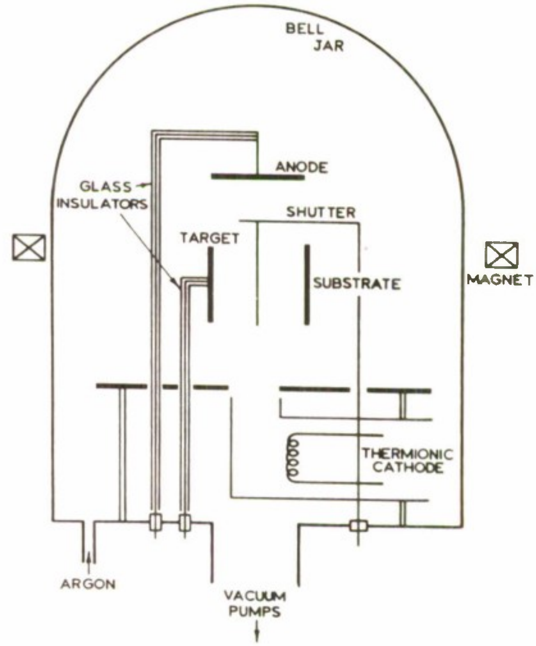
Tourmaline crystals have been successfully used as hydrostatic pressure transducers. They were found to be the most suitable type of piezo-electric material for underwater pressure measurements due to their characteristic of developing an electric charge under omni directional hydrostatic pressure.

Further advantages of tourmaline are that it is easily sectioned, has high mechanical strength enabling it to withstand loading pressures up to 100,000 lbf/in² (690 MN/m²) and is non hygroscopic. Minor disadvantages

are the necessity to obtain flawless crystals and the relatively low sensitivity of these crystals to applied pressure.

Transducers have been prepared by cutting and grinding slices of tourmaline crystals to a thickness of 0·0625±0·0025 in. (1·588±0·064 mm) before using an ultrasonic cutting tube to obtain 0·25±·001 in. diameter (6·35±0·025mm) discs from these slices. On decimalisation it is proposed to retain the same diameter but change the thickness to 1·6±0·05 mm. The discs are thoroughly cleaned and silver paste is burnished on their flat surfaces. The polarity of the crystals is then checked, the ' positive ' faces of two discs soldered together, and the resultant joint connected to the inner core of a low conductance, noise free co-axial cable. The screen of the cable is connected to the two outer silvered faces and the transducer lead waterproofed with a thin coating of wax.

For the type of transducer described, sensitivity is approximately 10mV/0·1μF/6·9MN/m^2 which, with amplification, has been found sufficient to measure peak pressures at 1·5 m from 1 g detonators or 100 m from a 500 kg charge.



Three electrode technique in vacuum bell jar.

Sputtering Techniques for Metallising Ceramics

A three electrode sputtering technique has been found to hold considerable advantages in metallising ceramic components prior to making metal/ceramic sealed joints. The process can be used with any grade of ceramic and is particularly useful with beryllia.

Sputtering is essentially a cold process and hence there is no risk of ceramics cracking or distorting as in the application of conventional high temperature sintered coatings. Overplating the metal coating with copper to provide a wetting layer for the subsequent brazing operation may also be performed using this technique. Sputtered layers are also very much thinner (approximately 1 μm) than sintered layers and in consequence the ceramic component may be machined to closer tolerance prior to metallising.

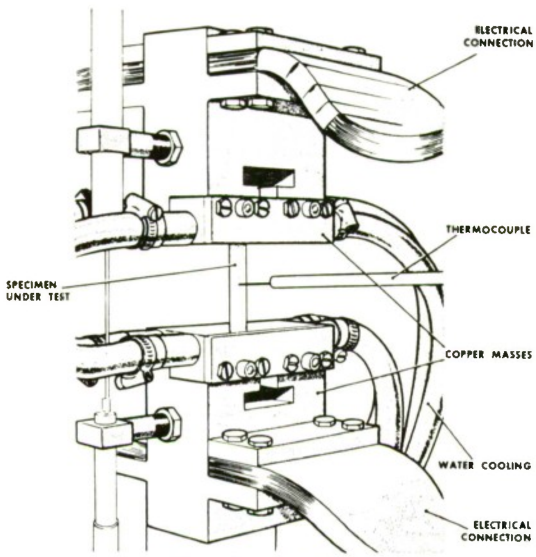
In experimenting with this technique, sputtering was carried out in a conventional vacuum bell jar using the three electrode technique. A discharge was maintained between the anode and cathode in a pressure of a few millitorr of argon. A magnetic field confined the plasma to a column of 80 - 100 mm diameter. The target, which was the material to be sputtered, and the substrate, the material to be coated, were spaced about 60 mm apart so that both were immersed in the plasma beam. A negative potential was applied to the target and positive gas ions bombarded the target causing material to be removed and sputtered. Deposition rates varied from 10 - 1000 Å/min (1 - 100 nm/min) depending on the material and voltage used. A rotatable target holder containing two separate target materials allowed the metallising layer and overplating to be applied consecutively without break in vacuum. The brazing operation, to connect metallised ceramic components to metal, was carried out either in a dry hydrogen atmosphere or in a vacuum furnace.

Various combinations of metals were tried in these experiments and primary layers of molybdenum, tantalum or tungsten followed by secondary layers of copper, silver or gold were found to produce successful leak proof seals.

A Thermal Cycle Test Machine

This weld thermal cycle simulator is capable of faithful reproduction of weld heating and cooling cycles in Charpy V-notch and other mechanical specimens. In addition it can simu-

late welding stresses by applying tensile loading to these specimens. The apparatus is useful for studying the effect of cooling rates on the mechanical properties of the heat affected zone (HAZ) in welds.



Tharmal cycling machine

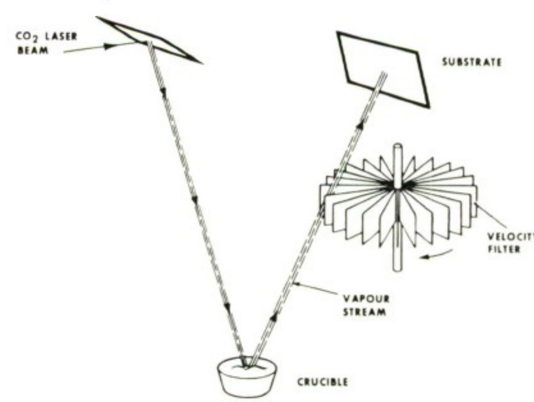
Specimens under test are held between two water cooled copper masses and directly heated by their own resistance to passage of the electric current from a 100 kVA welding transformer. Temperatures up to 1600°C, and controlled cooling rates varying between 3°C/s and 40°C/s, may be achieved by this means. The temperature of the specimen is measured with a thermocouple of very fine platinum/platinum rhodium wire spot welded to the specimen at a point midway between the grips. The output from the thermocouple is amplified and compared with a reference voltage from a function generator and any difference is used as a controlling signal to regulate the power supplied to the primary of the specimen heating transformer. The equipment can simulate restraint by applying tensile loading to the specimen at any point in the thermal cycle. This permits the use of the apparatus to be extended to tensile testing of materials at elevated temperatures. Severe oxidation of the specimen during heating is minimised by surrounding the specimen with an argon gas shield.

The weld thermal cycle simulator has been used for investigations into the effects of peak temperatures and cooling rates on the notch toughness of weld HAZ's in high strength steels. It can readily provide suitable specimens for examining the effects of stress relieving of welded structures. Using the tensile loading capability of the machine the effects of restraint in welding can be studied and the hot cracking tendency of materials determined.

The machine was designed and built at the Naval Construction Research Establishment in conjunction with A.E.I. Limited.

Particle Filtration Aids Production of Low Scattering Dielectric Mirrors

A novel particle filter has been used in the production of low scattering dielectric mirrors for laser applications with results which are only achievable by conventional means under conditions of extreme cleanliness and rigorous control of technique.



Laser mirror coating techniques have advanced to a point where optical losses are now very low. In some applications, however, it is desirable to improve this situation even further. Light losses are caused by scattering of incident light from small dielectric particles trapped within the layers of the mirror or by absorption of incident light due to impurities in the coatings. These impurities may be derived from the original evaporant or introduced during the coating process by, for instance, the evaporation of the vapour source boat material. In order to avoid contamination in this way

the surface of the evaporant can be heated by a carbon dioxide laser beam. However the efficiency of mirrors produced using this heating method is marred by a high level of scattering due to expulsion of particles from the vapour source.

In an experimental technique used to overcome this problem a particle filter was inserted between the source and substrate. The type of filter was a paddle wheel rotating at such a velocity as to trap particles and yet cause minimal interception of the higher velocity vapour stream. A 24 vane filter, driven by magnetic coupling through the walls of the vacuum chamber, provided cut-off velocities in the region of 50 m/s, compared with the calculated velocity of the molecules in the vapour stream of 100 m/s.

In order to check the effectiveness of this filter a standard mirror was prepared by a conventional process after rigorous cleaning of the evaporation plant, all metal surfaces being polished, and after utmost care had been taken at every stage to exclude dust particles. Whereas this mirror had a very low scatter level it must be emphasised that the extreme care necessary to achieve this degree of excellence is not ordinarily practicable.

A mirror prepared without any special precautions but using the velocity filter gave closely similar results. It is, therefore, considered that the particle filter is a more practical means of achieving very low scatter dielecric mirrors.

At a cut-off velocity of 50 m/s the filter has a marked effect on the deposition rate of the layers due to reduced transmittence of the filter. Also some very slight non-uniformity of coating was observed. This should, however, be overcome by suitable design of filter.

Retirement

W. L. Borrows
B.Sc., A.R.C.S., D.I.C., A.R.I.C.
(Photograph by Cyril C. Crouch)

On 31st December, 1970, Mr. W. L. Borrows, B.Sc., A.R.C.S., D.I.C., A.R.I.C., retired after thirty-seven years of Admiralty service, for the last sixteen of which he served as Superintendent (latterly Director) of the Admiralty Research Laboratory: a considerably greater length of time than that of any of his predecessors.

From Lincoln City school, the young Bill Borrows entered the Chemistry Department of the Royal College of Science in 1929 from where he graduated three years later to begin his Admiralty career at the Naval Ordnance Inspection Laboratory, Holton Heath in 1933. After another three years he joined the Admiralty Chemist's Department where, as one of a group of younger chemists, he found himself injected into the ranks of a long-established analytical group almost a generation older. It proved to be significant that, although he had from the beginning very firm views which he always expressed with confidence and vigour, he was rapidly accepted by the older stratum who recognized the value in their midst of a stimulating spirit. To the change in ACD wrought by the war years, Bill added his contribution during the decade he was a member of the staff, and this period was followed by a couple of years with the British Admiralty Delegation, later the British Joint Services Mission (Navy Staff) in Washington. This appointment was in utter contrast to the previous one, but his versatility was at once in evidence by the effectiveness with which he virtually laid the foundations of a post in the Scientific Adviser's Section upon which others were subsequently able to build as US/UK liaison developed. One of his major interests at that time was the newly emerging one of high energy fuels, and on his return to the UK he embarked, after a year with the Directorate of Aeronautical and Engineering Research, upon work with boron hydride, firstly at AML and later at ARL.

After four years as Head of ARL's Chemistry Group, the need for his administrative experience outweighed that for his experimental skill and, in 1954, he became Superintendent in succession to Dr. H. F. Willis.

Mr. Borrows has always been keenly interested in farming and for a number of years has participated in the farming activities of his brother, a professional farmer, but although the call to the land has been strong, in the event this has been adequately answered within his own garden which, entirely as the result of his endeavours, has provided a delightful setting for the mid-summer garden parties which have become so much a part of the ARL social scene. These have owed their undoubted success not only to the Director's horticultural prowess but also to the innate skill which, as a chemist, he has always displayed in the mixing of the drinks.

Similar skills have been demonstrated at his pre-Christmas parties which have been immeasurably enhanced by a " chemist's brew " of undefined and undefinable complexion which, rumour has it, has been the principal reason for the retention of a Chemistry Group for so long in an establishment heavily oriented towards Other Disciplines.

Thus, quite apart from the administrative and political skill with which he has successfully guides the affairs of ARL for the past many years, the encouragement that his example has given to the development of the other social activities at ARL has gone a long way towards the creation of that generally prevalent feeling of " belonging to the ARL family " which is so often expressed. He will be greatly missed.

NOTES AND NEWS

Admiralty Research Laboratory

In January 1970, on transfer from the Department of Education and Science, Mr. P. D. Greenall joined the Applied Psychology Unit to undertake statistical studies of the cost effectiveness of naval training activities. Other recruits in 1970 included Mr. P. D. Taylor and Mr. R. J. Strong while Mr. M. J. Hurn transferred from elsewhere in ARL. Also during 1970, Mr. N. C. Farnes left to take up a post at Brunel University; Mr. R. J. Miles was transferred to the Army Department, and Mr. H. C. W. Stockbridge, who had been seconded to A.P.U., returned to the Army Department. Lt. Cdr. J. D. S. Moore has been seconded to A.P.U. to take the place of Lt. Cdr. R. Hawketts, when his tour of duty at ARL comes to an end.

Two members of A.P.U. attended NATO Advanced Study Institute Courses, during summer 1970 Mr. K. Ellis went to Trieste for one entitled " Human Performance Theory," and Mr. P. D. Greenall went to the Civil Service College at Sunningdale for another entitled " Statistical Models for Education and Training ".

In July, Mr. E. Elliot, who is Head of A.P.U., and eight members of the Unit, attended the Symposium of U.K. Defence Psychologists at the Royal Military College of Science, Shrivenham. Members who read papers were Mr. K. Ellis, Mr. M. E. Court and Mr. N. C. Farnes.

Mr. P. R. Lindop attended the 28th U.S.N. Symposium on Underwater Acoustics in Washington on the 17th and 18th November and presented a paper entitled "A Collaborative Long Range Sound Propagation Experiment in the N.E. Atlantic."

Three members of the Laboratory, Mr. A. B. Mitchell, Dr. J. H. Foxwell and Mr. D. V. Hilborne together with Mr. R. Willmer and Mr. D. R. Hiscock of the Admiralty Underwater Weapons Establishment formed a U.K. team which made a three week visit during November to United States Navy Establishments.

Visits were made to six U.S. laboratories on the East and West coasts. The tight schedule laid on by the British Navy Staff Office in Washington proved highly successful which was made possible by the co-operation and welcome the team received at all the laboratories visited.

On the lighter side the team members took full opportunity of what spare weekend time was available to visit friends and places in almost the four corners of the country. On one occasion the mean free path between the five team members approached 2000 miles. Mr. P. L. Rogerson visited the Defence Research Establishment at Halifax, Nova Scotia in November at the invitation of the Canadians to discuss high speed marine craft. Mr. D. Johnson attended a course on Mixed Flow and the Centrifugal Pump Design at the Von Karman Institute in Brussels during December.

We were delighted to learn that Dr. D. E. Weston, who was awarded a D.Sc. by London University on 8th December, has been chosen to be the recipient of the 1970 British Acoustical Society's Annual Silver Medal. This medal is being presented for the first time this year, and is awarded to those, who, in the opinion of the society, have made significant contributions to the field of science and acoustics. It is a condition of the award, that the recipient should present a paper to the society's Spring Meeting on 5th/7th April, 1971 at the University of Birmingham. Congratulations David.

Mr. W. L. Borrows, centre, with Mr. N. B. Wood, left, and Mr. M. Divey.

On Friday, 11th December, ARL staff gathered at the Feltham Hotel for a special Dinner and Dance to mark the occasion of the retirement of Mr. W. L. Borrows, who has been their director for 16 years. The staff arranged the event and invited Mr. and Mrs. Borrows as the guests of honour. Some 160 people sat down to enjoy a seasonal dinner menu after which Mr. H. Margary, in jovial and entertaining mood, proposed a toast " to Bill and Helen Borrows ". The director, in his reply, offered a final toast to the future of ARL and its staff. Dancing and jollification continued until the early hours.

The director a'so invited all members of his staff to join him for a farewell drink on 31st December, his final afternoon as director. This party was also the occasion of the presentation by the staff of farewell gifts, and these were presented by the Chairman of ARL Staff Associations Committee, Mr. N. B. Wood, who also unveiled a portrait of Mr. Borrows for ARL's " Directors Gallery ".

Mr. E. Stevens retired from the RNSS on August 10th, 1970 after 30 years' service.

Mr. Stevens had had a varied career. After leaving school he studied at the Royal Academy of Music and later joined the D'Oyly Carte Opera Company as a singer. He toured with the company for some ten years during which time he visited the United States on three occasions and took part in the film version of the Gilbert and Sullivan opera " The Mikado ".

Mr. E. Stevens, right, with colleagues at the presentation ceremony.

This career ended with the outbreak of war and in 1939 he joined the Underwater Countermeasures and Weapons Establishment at *Vernon*, Portsmouth as a Laboratory Assistant. The next twenty years he spent as a member of a trials team developing and testing mines and countermeasure devices, often working in outlandish places. In 1951 he was promoted to Senior Scientific Assistant.

However, in 1959 the " Way-Ahead " re-organisation programme caused the move of UCWE to Portland and Mr. Stevens was transferred at his own request to ARL. Here, for the past eleven years he worked in the Library, giving invaluable service. In 1965, on reaching official retirement age he was awarded the Imperial Service Medal.

To mark Mr. Stevens' retirement the Director, Mr. W. L. Borrows, before a large gathering of the staff, presented him with a wrist watch on behalf of his many friends and colleagues at ARL.

After nearly 21 years of endeavour in the Fluid Dynamics Group at " Upper Lodge " Admiralty Research Laboratory, **Dr. Hans Ritter** has moved into the service of ARL's friendly neighbour the " National Physical Laboratory ", as head of the Ship Resistance and Propulsion Branch, at Feltham, Middlesex.

He leaves behind a record of steady achievement, first in his contribution to the design and instrumentation of the Group's major facilities, the 30″ Water Tunnel and the Rotating Beam

Dr. H. Ritter, left, with Mr. Borrows.

Dr. G. M. Voglis

Channel, and then, in the years that followed, in the research into Drag Reduction Stability, and Control and Propulsion systems for torpedo and submarines.

The Rotating Beam Channel still remains after 15 years one of the fastest and most rigid of its type in the world today. That its virtues have become known is evident in the steadily increasing number of requests for its use made by other establishments both here and abroad.

Those at ARL who have worked beside him are aware that they have lost an able scientist and an interesting and stimulating colleague. Yet it is satisfying to know that although his surroundings have now altered, neither they, or the faces around, will be entirely unfamiliar to him, and his move is itself a part of the continual interweaving of the affairs of the two departments that inevitably results from common interest and geography.

He goes with everyone's best wishes for his further success and their hopes of continuing, although at somewhat greater distance, the happy associations of the past.

Dr. G. M. Voglis, Senior Principal Scientific Officer (Special Merit) at the Admiralty Research Laboratory, retired from Admiralty Service on 31st March, 1970.

He joined the RNSS at SRE Birmingham in 1941, where during the war he was engaged on radar research.

Joining the Admiralty Research Laboratory in 1945 he made important contributions in the underwater field. His development of sector scanning sonar systems has led directly to the evolution of a number of sonar equipments and in particular to the construction of the ARL Scanning sonar that has recently found successful employment in civil oceanography and fisheries research.

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Admiralty Surface Weapons Establishment

Dr. J. Croney and Mr. A. Woroncow have been awarded the Lord Brabazon Award by the Council of the Institution of Electrical Engineers for their paper on "Radar Polarization Comparisons in Sea-Clutter Suppression by Decorrelation and Constant False Alarm Rate Receivers" which was considered to be the outstanding paper published on Radar Engineering in the Institution's Journal during 1969. This is the third occasion on which Dr. Croney has received an Institution premium, an honour which is shared by very few.

The Establishment organised two exhibits for the Institute of Physics and Physical Society's "Physics at Work" exhibition held in Portsmouth during December. The first of these demonstrated the use of gyros for providing a stable vertical reference in ships, and the second demonstrated the Doppler principle with model electric racing cars using a solid-state X-band transmitter-receiver, the receiver of which was arranged to have an audible output.

Mr. P. F. C. Griffiths has returned from duty with the POLARIS Post-Patrol Analysis Group. Both he and Mr. C. Wilkes from DNPR have joined the Assessments Group at ASWE. These two officers have been replaced by Mr. P. E. P. Pearce and Mr. N. A. Godel respectively.

Mr. K. M. Harvey has returned to ASWE after two years with WRE Salisbury, South Australia.

Recent visitors to the Establishment have included Dr. Petrie—Chief of the Canadian Defence Research Staff, Dr. M. Woods — the Director of WRE Salisbury, South Australia, Captain R. H. Kerkhoven—Director of Research and Development to the Royal Netherlands Navy, and Dr. Fergus Allen — Scientific Adviser to the Civil Service Commission.

Messrs. W. Delany, D. S. Mountain and W. Harmer have recently returned from Bermuda after sea trials on H.M.S. *Grenville*. These trials were to test a new light-weight mounting system for two radar arrays which are required to be stabilised and to rotate independently. The servo-mechanisms were hydraulic and the heavy pump-set was at the base of the mast. The trials were carried out in rough weather and were successful.

Mr. R. McGinn

On 2nd May, 1970 ASWE suffered a very sad and untimely loss in the death, after an illness, of **Mr. R. McGinn,** Principal Scientific Officer.

Ron McGinn, a Scotsman, was born in 1915 and spent the early part of his life in Edinburgh. He was educated at the George Heriot School and later graduated in Electrical Engineering from the Heriot-Watt Engineering College of Edinburgh University. In 1938 he joined the Automatic Telephone and Electric Co. at Liverpool and worked as an equipment engineer on various special projects throughout the war years. After the war, he was leader of the team at ATE which developed the first on-line security equipment for telegraphy and which was subsequently used by the R.N. on all strategic circuits for many years.

He joined the RNSS at ASRE at Witley in 1951 as a temporary SSO just before the return of the Establishment to Portsmouth and, for several years, he was a very highly valued member of the team under Dr. Ralph Benjamin developing the Comprehensive Display System which set the trend, literally, for the rest of the world in control methods for Air Defence. He became Project Leader for the CDS systems in H.M.S. *ARK ROYAL* and the Hampshire Class DLG's and was promoted to PSO in 1959. After a period as the Weapon System Engineer for the ADA Weapons System in the second four of the Guided Missile Destroyers, he was appointed Head of ASWE's Equipment Installation Division (IX) in 1964 and remained in this key position until transferred in October 1969 to the then newly formed Ship Weapon System Engineering Section.

It was in the field of System Engineering and Installation that he will best be remembered by so many people, not only at ASWE but among those with whom he constantly dealt in the Ship Department at Bath. He was a professional who really enjoyed his work; and part of his strength lay in his very likeable nature which enabled him to do things by persuasion which, in the nature of organisations, could not be ordered.

Nobody ever saw Ron McGinn depressed and, unless one knew him very well indeed, would never suspect that he suffered a great deal of serious illness throughout his life, including poliomyelitis halfway through his career at ASWE, but which he shrugged off as just another vexation. His was a great spirit which will be missed at Portsdown for a long while to come.

With the retirement of **Aleksander (Sacha) Woroncow,** ASWE says goodbye to the last of that contingent of Polish scientists who served it with such colour and distinction during and since the last war.

Woroncow was born in 1909 in Warsaw where he grew up to attend the university and graduate with the degree of Dipl.Ing. He was first employed in the Polish Broadcasting Research Department, and later as a civilian

scientist at the Polish Air Force Establishment. At the invasion of Poland he had the good fortune to be at the Rumanian border on a mission connected with the receipt of equipment for the Polish Air Force. This made possible his subsequent enlistment in the Free Polish Air Force, and his arrival in England, where he joined ASE in 1941 to work in the Radar Displays Division at Witley, under Mr. D. Stewart Watson. The long list of Woroncow's papers in this field, shows the diversity of his inventive mind in Time-Base and Pulse Forming Circuits. A special achievement of those days was his truly pioneer work on RF power supplies for CRT drive circuits. Those who recollect struggling with the vast bulk and weight of the old eht iron-cored transformers, will vividly appreciate the revolution which he wrought by this work.

After the war the pace of his invention quickened when he worked in close consort with Dr. Ralph Benjamin on the Comprehensive Display System (CDS) and Action Data Automation (ADA). A most noteworthy achievement was the High Speed Symbol Writing Equipment (*J.R.N.S.S.*, Vol. 15, 1960, page 250) which allowed well-formed numbers, letters, and even line diagrams of fighting vehicles, to be drawn-in (wing interlaced markers) on PPI displays, by the clever application of ferrite cores driving power transistors. During this period (1950) he married Aldona (the cousin of another of ASWE's Polish scientists, the late Stefan de Walden) and in 1952 their gifted daughter, now at Cambridge University, was born.

In 1962 he joined the Antennas Division at Funtington, to work on the control circuits for ferrite phase shifters of phased array antennas, and again quickly made his mark. He began also a co-operation with Dr. J. Croney on the decorrelation of sea-clutter by high speed antenna scanning, building complete displays (normal CRT and Direct View Storage Tube) to follow a 1,000 rpm antenna. Some difficult Time-Base problems were involved; he not only solved them but produced concurrently a new type of True i.f. Logarithmic Amplifier for this work. For the subsequent published papers he was awarded, with Dr. Croney, the Clerk-Maxwell Premium (1966), the Lord Brabazon Award (1966), and again the Lord Brabazon Award (1966) of the IERE, a triple distinction shared by few.

Sacha's infectious sense of humour was a continual pleasure to those who worked close

Mr. A. Woroncow

to him, sharing his enthusiasms at the laboratory bench. When things went wrong his expletives were picturesquely pungent yet never unprintable. He would co-operate with anyone and was entirely devoid of the petty prides and prejudices of rank. His scientific knowledge and interests are astonishingly wide; in gardening he played at grafting and aims at new hybrids, where most of us count our blessings in brussels sprouts.

He leaves ASWE to take up a research appointment at the University of Southampton where he will be surrounded by young people as befits his own outstanding youthfulness of heart. Through ASWE's link with the University he will not be entirely lost to us, and we wish him well in this new career. Retirement it certainly is not; for him " To travel hopefully is better than to arrive, and true success is to labour ".

G. F. (Fred) Cuerden retired from the R.N.S.S. at the end of August after 45 years' employment in Naval establishments. He started his career as an electrical apprentice at Rosyth Dockyard in 1925, later transferring to Portsmouth, and moving into the Drawing Office at Portsmouth Dockyard in 1936.

From 1937 to 1954 he worked on fire control design, from 1937 - 39 for Director Torpedoes and Mines, Whitehall; 1939 - 44 at D.N.O. Bath, and from 1944 - 54 at A.G.E. Teddington. While at Teddington he was twice promoted, to X.O. in 1946 and to S.X.O. in 1952. During this period he was deputy project leader for the Yellow Fever tracker and designed the hand-ball control, which he regards as the forerunner of the present day rolling ball control.

Mr. G. F. Cuerden

Fred spent 1954 - 60 at A.G.E. Portland still associated with fire control, this time for the Army.

The last ten years have been spent at A.S.W.E. Portsdown designing stabilisers for G.W.S.31, organising the data handling for *Sea Dart* trials sites and, latterly planning G.W.S.25 trials installations.

In his younger days he played representative cricket and soccer for the Admiralty but nowadays he has taken up golf, much to the discomfiture of the other A.S.W.E. club members.

Mr. S. Boronski, with colleagues, at his retirement presentation

Stanislaw Boronski, a wartime Polish officer, came to England in 1943 *via* a North African prisoner of war camp. A graduate electrical engineer with experience of radio transmitters and receivers his skills were valued at A.S.E. Waterlooville where he was concerned with the development and evaluation of microwave valves. After the war his interests included flying, tennis, photography and music. In 1950 Mrs. Boronski was able to join him in England where they have a home in Fareham.

Mr. Boronski's devotion to his work led him to make a number of significant contributions to the field of microwave research and development. These have materially contributed towards the defence of this country. Although an individualist his many colleagues greatly valued his expert advice.

Mr. Boronski was presented with an Artists Oil Colour Box on the 28th September 1970 to mark his retirement from A.S.W.E. after 27 years of service.

Admiral Sir Michael Pollock, K.C.B., M.V.O., D.S.C., who was Director of Surface Weapons from 1960 to 1962 has been appointed Chief of Naval Staff and First Sea Lord from March 1971, in succession to Admiral Sir Peter Hill-Norton, C.C.B.

Admiralty Underwater Weapons Establishment

The Undersea Warfare Study Panel of TTCP Sub Group G held its tenth meeting at AUWE from 21 - 25 September 1970 when the meeting was chaired by Mr. D. R. Hiscock. Panel members from Canada, Australia and the USA included Mr. J. Hudson, Director of Maritime Operational Research, Canadian Defence Research Analysis Establishment, one time member of the RNSS at UCWE, and Mr. M. D. Frost, Australian National Leader, who will be remembered as an exchange scientist with DNOS and AUWE a few years ago.

The panel's discussions centred on the changing requirements for ASW in the light of the addition of air flight anti-ship missiles to the submarine's weapon outfit. A wide range of expertise, from other MOD(N) and Ministry of Technology establishments, was drawn upon to contribute to a broad scrutiny of the problem.

The fifth NATO Degaussing Symposium was held in London from 21 - 24 September 1970. This meeting of degaussing experts is held every three years under the auspices of the NATO Mine Warfare Technical Panel and on this occasion the United Kingdom were hosts to 51 delegates representing 11 NATO

countries. The Chairman of the Symposium was Mr. H. A. Hudson and the opening address was delivered by Mr. B. Lythall, CS(RN).

The four papers presented by the United Kingdom were given by Mr. D. R. Thompson, Mr. C. Foggon and Mr. A. B. Cotton of AUWE, and Cdr. F. W. Miller, RN(Ret.) of DG Ships.

On Friday, 25 September, the delegates visited AUWE when work on mine counter-measures was demonstrated. The visit concluded with a further demonstration at the Land Degaussing Range.

The following two papers by Dr. A. Freedman have been published in the July 1970 issue of the *Journal of the Acoustical Society of America.* "Transient fields of acoustic radiators" and "Sound field of plane or gently curved pulsed radiator."

Members of the Institution of Mechanical Engineers visited the Establishment on 7 October. After introductory talks on materials, diving, weapon discharge and computer aided design, they toured various laboratories where they were shown the relevant hardware.

Other notable visitors have been Rear Admiral J. R. McKaig, Assistant Chief of Defence Staff (Operational Requirements), making his farewell visit to the Establishment on 30 September, before taking up his new appointment as Flag Officer Plymouth; the TTCP Panel on Military Oceanography on the previous day, and Mr. M. W. Van Batenburg, Director of the SACLANT ASW Research Centre, La Spezia, on 2 October.

Mr. W. J. McCarthy, Chief Experimental Officer, is to be congratulated on the award of the Imperial Service Order in the Queen's New Year Honours List.

The First Sea Lord, Admiral Sir Peter Hill-Norton, K.C.B., visited Portland on 11th November, and took time off from touring ships to spend two hours in A.U.W.E. where he was given a presentation on future anti-submarine measures, also on 11th November the Student Chemical Society of Bristol University visited A.U.W.E., and were given presentations with the accent on Materials, and a brief tour of laboratories.

Messrs. R. W. Willmer and D. Hiscock of A.U.W.E., together with Messrs. A. B. Mitchell, J. H. Foxwell and D. V. Hilbourne of A.R.L., recently visited a number of U.S. Navy R. & D. Establishments for torpedo R. & D. discussions. The U.K. team were well received by all concerned and the success of the visit was due in no small way to the very good staff work by the British Naval Staff in Washington.

The annual meeting of N.A.T.O. Military Agency for Standardisations, Mine Warfare Working Party and Technical Panel was held in Munich over the last two weeks of November 1970. The U.K. delegation consisted of Cdr. G. de Courcy-Ireland (D.N.W.), Lt. Cdr J. Wilson (Captain M.C.M.), Lt. Cdr. M. Chapman (H.M.S. *Vernon*), Lt. Cdr. (Rtd.), S. Parsons (D.G.W.(N)), and the following members of A.U.W.E.: Messrs. H. Hudson, C. Harrington and D. F. Walker—the last as Chairman of the M.W. Technical Panel.

The German Navy, not having its own "home" in Munich, had borrowed excellent facilities from the German Air Force at Neubiberg Airfield some 15 miles out of Munich.

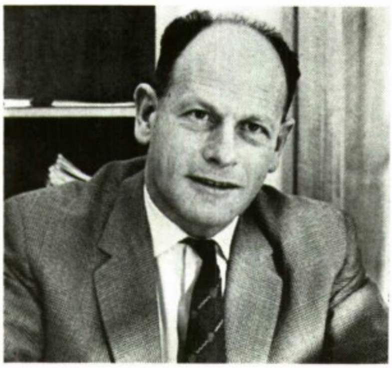
The first week was occupied by the meeting of the Technical Panel which was split into two groups each covering given areas of operational research, minesweeping and clearance diving. However, the U.K. introduced a much needed breath of fresh air into the proceedings by delivering an introductory paper on the impact which super-tankers and other very large bulk carriers may have on mine warfare. The "books" section of the Joint Mineware and Technical Panel also held its meeting during the first week—this is the section which deals with the N.A.T.O. publications ATP-6 and ATP-24.

In the second week the Joint session of the Working Party and Technical Panel and later the M.W. Working Party meeting took place. Much of the business still concerns doctrines and tactics in minesweeping despite the U.K's hope (expressed at the 1969 meeting) that more effort on minehunting should be presented. However, a small start in that direction was made by the U.K. by Captain M.C.M's representative introducing the first of his General Memoranda on Minehunting with the promise that they could be made available to all nations and could in the long run appear after full evaluation, in the tactical books.

The German Navy provided a couple of outings. The first for the benefit of delegates' wives was a trip around Munich including a visit to the site of the 1974 Olympic Games where work is proceeding apace. The second

was held on the middle Saturday when three coach loads of delegates and their wives and German hosts had an enjoyable (despite the weather) tour into the nearby mountains visiting Garmisch-Partenkirchen and Oberamergau.

Next year's meeting may take place in Washington with the United States as hosts, but this is by no means certain owing to the travelling distances involved.



Dr. Ralph Benjamin, Director, AUWE, has been awarded the Degree of Doctor of Science (Engineering) in London University.

The Vice-Chancellor, acting on behalf of the Senate, has conferred the Degree in recognition of Dr. Benjamin's work in the field of general electronics.

Dr. Benjamin has also recently been elected to the Council of the British Acoustical Society.

The death of **Charles Montagu Dering,** M.B.E., of the Admiralty Underwater Weapons Establishment, occurred on 26th November 1970. He was 64 years of age. His many friends in the R.N.S.S. and the Navy will learn of his death with deep regret.

Charles Dering entered Admiralty service in 1922 as an apprentice electrical fitter at Portsmouth Dockyard. His later success in the Draughtsman's Examination led to his appointment in 1929 to H.M.S. *Osprey,* the Navy's anti-submarine research establishment at Portland, where he became a member of a small design team.

Mr. C. M. Dering, M.B.E.

Following the outbreak of war, he was evacuated with the establishment to Fairlie, Ayrshire. During this time he made many friends with whom he never lost touch.

At the end of the war, when anti-submarine research was concentrated in H.M.U.D.E. (now A.U.W.E.), he returned to Portland where he was engaged on project work, associated chiefly with sonars which were eventually fitted in a major warship. In 1958 he became a member of the ship engineering group, and the remainder of his career was spent in this work. He became group leader in 1962 with the rank of C.E.O.

In recognition of his part in the war effort he was deservedly awarded the M.B.E. in 1953.

As a young man he played cricket, tennis and badminton, and was a founder member of the '*Osprey* Civilian Sports Club'.

Charles will be sadly missed, not only for his good work, but also for his kindness and loyalty to his friends. We extend our sincere sympathy to his widow and his family.

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Naval Aircraft Materials Laboratory

Mr. R. R. Diaper attended the third meeting of the NATO Aviation POL Handling Equipment Working Party at Neubiberg, Germany, from 14th - 21st September, 1970.

Rear Admiral J. E. Dyer-Smith, RN, Director General, Aircraft (Naval) visited the laboratory on 16 October, 1970, and Mr. J. W. Snowdon, SSP(N), on 18 November 1970.

M. Cordazzo and M. Lotan of the Société Nationale d'Etude et de Construction de

Moteurs d'Aviation visited the Laboratory on 12th November, 1970, to discuss N.A.M.L's spectrometric oil analysis programme. S.N.E.C.M.A. are concerned jointly with Rolls-Royce in the manufacture of the Olympus 593 engines for Concorde.

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Naval Construction Research Establishment

Admiral Pollock, Controller of the Navy, visited NCRE on September 21, 1970. Accompanied by Mr. K. Evans, Superintendent and Mr. I. Campbell, Chief Scientist, Controller toured laboratories at the South Arm and St. Leonard sites and discussed various aspects of the work with senior staff.

Sir Martin Flett, 2nd Permanent Under Secretary of State for Equipment in MOD visited NCRE on November 4, 1970. Sir Martin was shown round the laboratories and discussed items of work with the Superintendent and the Chief Scientist.

Messrs. J. Haywood and P. Wishart visited the USA during October for discussions at several Naval establishments in the Washington area. Mr. Wishart also attended the 41st Shock and Vibration Symposium at Colorado Springs, Colorado.

Leonard R. J. Knight retired from the RNSS on 31 October, 1970 after over 19 years' service all of which were spent in the Mechanical Testing Laboratory.

Mr. L. Knight, centre, with colleagues.

Being born in Cornwall and educated in Scotland developed in Len Knight a character which was a blend of independence tempered with loyalty and generosity. On leaving Dunfermline High School Len felt the call of the sea in his Cornish blood, and joined the Royal Navy as a boy entrant. Always proficient at sports and an excellent marksman he was soon classified as a 'natural' gunner and it was as a C.P.O. Gunnery Instructor he completed his active naval service. Len soon found a way of serving his old love in a civilian capacity by joining the RNSS in 1951. At NCRE, first as a Scientific Assistant and later as a Senior Scientific Assistant, he gained the respect of his colleagues and 'management' alike through his work in the MTL and his staff institution activities.

In making a presentation of a coffee set and percolator the Chief Scientist, Mr. I. J. Campbell, paid tribute to Mr. Knight's long and devoted service to the Admiralty and wished him a long and happy retirement in his new home back in the West Country.

Cdr. P. Newton, right, with Mr. J. Campbell, Chief Scientist.

Peter G. Newton (Cdr. RN) retired on 30 November, 1970 after 20 years in the RNSS and a total of 47 years' service with the Navy Department. Peter Newton who was born in Hampshire, came from a family with a tradition of service in the Royal Navy. He entered the RN College, Dartmouth in 1923 to start a naval career which was to extend through the period of World War II. Present at the first naval action at Narvick, he was serving in H.M.S. *Repulse* when she was sunk, together with H.M.S. *Prince of Wales*, in December 1941. On retiring from the Royal Navy as Lieutenant Commander in 1949 he joined the RNSS as a Senior Scientific Assistant at ASRE Radar Station, Tantallon in 1950. After trans-

ferring to NCRE in 1951 he became a member of the Materials Section and continued in that department until his retirement.

An all round sportsman, in his younger days Peter Newton distinguished himself as a tennis player at the same time counting rugby, hockey, cricket and water-polo among his athletic activities.

In making a presentation to Commander Newton of a table lighter and a copy of Peter Kemp's book *The History of the Royal Navy* the Chief Scientist Mr. I. J. Campbell paid tribute to the long and devoted service Commander Newton had given to the Royal Navy and the Navy Department and said that he hoped these gifts would remind him of his many friends at NCRE.

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Naval Scientific and Technical Information Centre

Head of NSTIC attended the one day Conference on Information Analysis Centres held in Amsterdam, Holland on 10 November 1970. The Conference was organised by the NATO Technical Information Panel of which Mr. Hinkley is one of the two UK representatives.

Papers on the subject were presented by speakers from the Battelle Memorial Institute, the Société Nationale Industrielle Aerospatiale, the UK Atomic Energy Authority, and the Admiralty Oil Laboratory.

Pending the production of the proceedings, copies of these papers are available on loan from NSTIC.

Many matters of mutual interest in the field of scientific and technical information were discussed when members of the Navy Departments' Technical Information Services met at the 22nd six-monthly meeting held at the Ministry of Defence, Whitehall on 4 November 1970. After the business meeting the representatives toured the permanent Defence Equipment Sales Exhibition maintained in the Main Building by the Director of Sales.

Many had been unaware of this display and were interested to see some of the equipment with which they were familiar in their own establishments.

The following Techlinks originating from Naval research have been issued:

No. 493. Hydrostatic Pressure Measurement using Piezo-Electric Transducers.

No. 494. A survey of Thick Film Technology.

No. 503. Automatic Switching Unit.

No. 539. A Thermocouple Spot Welder.

No. 544. A Reliable Gland for Rubber Cables.

No. 547. Screen Printed Thick Film Capacitors.

No. 550. Sputtering Techniques for Metallising Ceramics.

No. 551. A High Energy Impact Testing Facility.

No. 580. Blade Profile Tracing.

No. 588. Particle Filtration Aids Production of Low Scattering Dielectric Mirrors.

No. 591. A Thermal Cycle Test Machine.

No. 707. Design of Thick Film Microcircuits.

No. 720. Movable Thermocouple Probe for Surface Temperature Measurements.

Specialised aspects of work in Naval Research and Development Establishments have been publicised in the following press releases:

No. 1/70. Radar Clutter Reduction Techniques—Digital MTI Cancellers.

No. 2/70. Navy Departments at the Physics Exhibition.

No. 3/20. World Record in Simulated Deep Dive.

No. 4/70. Promising Areas for University Work on Fracture in Engineering Materials.

No. 5/70. Open Days at the Admiralty Engineering Laboratory, West Drayton.

No. 6/70. Brittle Fracture in Steel Structure.

No. 7/70. Symposium on Trawler Safety.

No. 8/70. Naval Materials—Current and Future Problems.

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Services Electronics Research Laboratory

Mr. T. James has been awarded the Imperial Service Medal. It was presented to him on 7th October by the Director. Mr. James is a founder member of S.E.R.L. having come to Baldock in 1945 to work on miniature rugged valves. He has, since then, helped in the development of a wide range of semiconductor devices.

Dr. D. R. Wight visited the U.S.A. from 15 - 30th August to attend the International Conference on the Physics of Semiconductors at Cambridge, Mass., and to visit various laboratories working on semiconductor luminescent devices.

The European Conference on Ion Implantation at Reading University, 7 - 9th September, was attended by Mr. R. F. Webber and Dr. R. M. Allen. Dr. Allen presented an invited review paper entitled 'Implantation of Compound Semiconductors'.

Mr. P. Brook presented a paper 'Physical Limits on High Power Operation of I.M.P.A.T.T. Diodes' by himself and Mr. K. G. Hambleton, at the 8th International Conference on Microwave and Optical Generation and Amplification, Amsterdam, 7 - 11th September. Mr. Hambleton also attended the Conference.

In company with Mr. A. A. Turnbill of Mullards Research Laboratory, Redhill, Mr. P. G. R. King visited various laboratories in the United States during the period 14 - 25th September to see and discuss American research and development work on photocathodes based upon III - V semiconductors.

Several members of S.E.R.L. attended the 4th International Solid State Device Conference at Exeter University during 15 - 18th September. At this Conference, Mr. S. D. Lacey presented a paper entitled 'The Degradation of Gallium Phosphide Electroluminescent Diodes'; Mr. J. A. Raines gave a paper on 'Silicon Avalanche Diodes with Optimum Noise Performance'; and D. R. Wight presented a paper, written by himself, J. C. H. Birbeck, J. Trussler and M. L. Young, on 'The Correlation of Cathodoluminescence Intensity with Electroluminescence Efficiency in N-doped Gallium Phosphide Diodes'. Mr. K. G. Hambleton was a member of the Conference programme committee.

Dr. S. Bass visited Switzerland in September to attend a meeting of the Swiss Crystallographic Society and also a conference in Zurich on 'Crystal Growth and Epitaxy from the Vapour Phase'.

Dr. C. H. Gooch and Mr. M. C. Rowland attended the 3rd International Symposium on Gallium Arsenide at Aachen, 4 - 8th October, 1970.

Dr. Jerzy Starkiewicz who had worked both at A.R.L. and S.E.R.L. since arriving in England during the war years died during the summer of 1970.

Known to his many friends as George, he was outstanding in the research field of electronic devices and, in particular, on infra-red detectors and electroluminescence. It was during his stay at A.R.L. and the early years at S.E.R.L. that Jerzy Starkiewicz made his well-known contributions to the technology of infra-red detectors. Latterly he had concentrated on electroluminescence in crystalline solids and made the important discovery of red light emission from P-n junctions in gallium phosphide.

Jerzy was an experimental physicist of quite extraordinary skill and insight and a particularly warm-hearted colleague who will be greatly missed.

Our sympathies go to his widow, Molly, who is still at S.E.R.L.

The passing of **Sidney Bailey** at the early age of 54 will be deeply felt, not only by his colleagues at S.E.R.L. but by all who knew him. Although he had been ill for several months his death came as a shock to his many friends.

Sidney began his career as an apprentice to a commercial photographer during which time he gained a thorough and practical knowledge of the art of photography. Called into service during the war he joined a R.A.F. Photo Unit

seeing service abroad. In 1946 on leaving the forces, he entered the Combined Operations Experimental Establishment at Fremington, North Devon remaining with it until after its assimilation with the Admiralty in 1955. He transferred to A.U.W.E. Portland, where he was promoted to Principal Photographer moving to S.E.R.L. in 1966 where he headed the photographic department. He was an active member of the I.P.C.S. for which he chaired the Photographers' Panel.

Our sympathy goes to his widow and the young son he leaves.

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Services Valve Test Laboratory

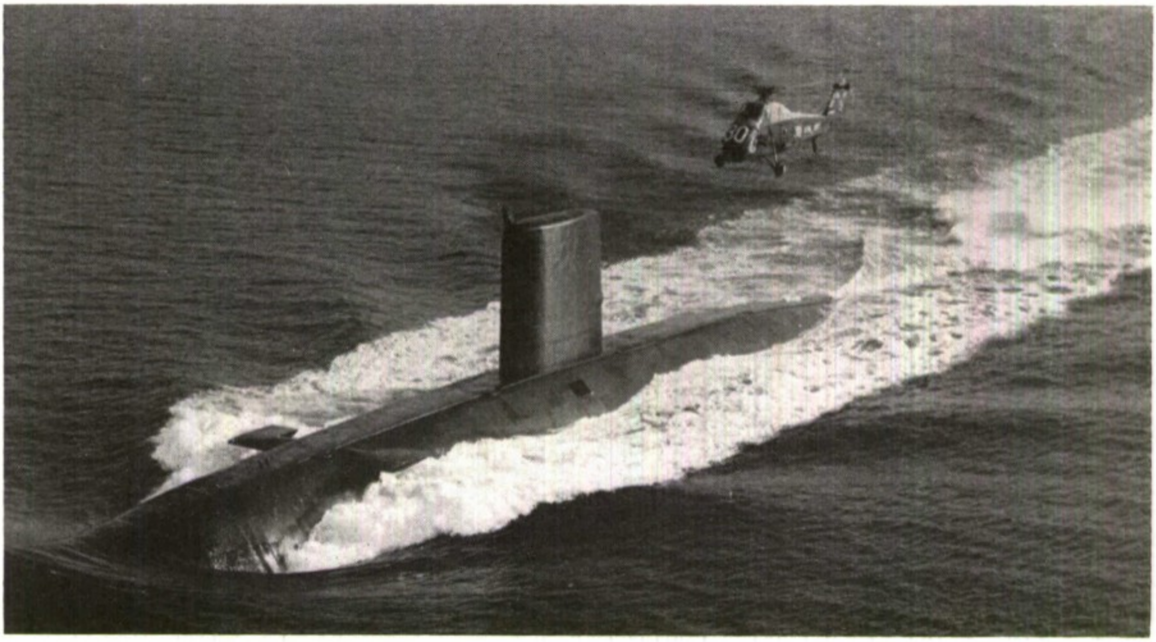
Mr. A. M. A. Sczaniecki retired from the R.N.S.S. on 1st November 1970. He came to this country as a member of the Free Polish Army shortly after the outbreak of the 1939 - 45 war. He joined Admiralty service in January 1942 and was employed as an Experimental Officer as A.S.E. Extn., Waterlooville in the Valve Division under the late H. G. Hughes. He arrived with a wide and thorough knowledge of electronic instrumentation and soon became deeply involved in measurement problems related to the performance of electronic tubes. In 1944 he was promoted to S.E.O. and in 1952 he transferred to S.V.L.T.E. Liss, which was later re-located at Haslemere as S.V.T.L. He was promoted to P.S.O. in July 1955.

To his English acquaintances, the correct pronunciation of his name was found to be somewhat confusing and, for the sake of simplicity, he soon became known affectionately (and phonetically) as "Channy" by his colleagues and associates in his working circles. His command of the English language became quite remarkable and he will tackle discussion on any topic from science to philosophy. In his field of work he was quickly recognised as an enthusiast with a very wide knowledge and a strong tenacity of purpose. He always aimed at perfection and, not unexpectedly, this gave rise to complications on occasions. In a different and lighter vein he is well remembered by his wartime friends in Waterlooville as an "instructor" in Polish croquet which appeared to be rather less gentlemanly than its English counterpart.

In his private life he has taken a very active part in organisations related to the activities and welfare of the Polish community in Britain and he intends to continue this work now that he has retired. In recognition of his services in this cause Mr. Sczaniecki was recently awarded the Papal medal of Knight Commander of the Order of Pope Saint Sylvester and other awards by the Roman Catholic Church.

All his friends and colleagues will wish both Mr. and Mrs. Sczaniecki many long and happy years of retirement.

THE NUCLEAR FLEET



H.M.S. WARSPITE WITH WESSEX

The Navy's first nuclear submarine, H.M.S. *Dreadnought*, re-commissioned on 10th September 1970 under the command of Commander Alan Kennedy, R.N., after a refit at Rosyth. The refit, which began in May 1968, is the first in which a nuclear submarine has been overhauled in the U.K., and the opportunity has been taken to undertake a complete examination of the whole nuclear plant. Nuclear safety requirements and the great complexity of these submarines has necessitated the development of many new management techniques and procedures.

The experience thus provided has paved the way for Rosyth Dockyard in its task of refitting Polaris submarines, and many of the lessons learned have already been applied in the refit of H.M.S. *Resolution*, which is currently in hand.

Books Available for Review

Offers to review should be addressed to the Editor

American Welding Society Welding Handbook.
6th Edition. Part I:
Fundamentals of Welding.
Edited by A. L. Phillips.
Macmillan, 1968. 600 pp. £6.00 (120s.). (No. 1714)

Noise and Acoustic Fatigue in Aeronautics.
E. J. Richards and D. J. Mead.
Wiley, 1968. 512 pp. £7.50 (150s.). (No. 1721)

Engineering Hydrology.
E. M. Wilson.
Macmillan, 1969. 182 pp. £2.75 (55s.). (No. 1726)

Cybernetics Simplified.
A. Porter.
English Universities Press, 1969. 159 pp. £1.10 (22s.). (No. 1732)

Plastic Design of Frames.
Sir J. Baker and J. Heyman.
Cambridge University Press, 1969. 226 pp. £2.75 (55s.). (No. 1752)

Applied Heat for Engineers: SI Units.
J. B. O. Sneeden and S. V. Kerr.
Blackie, 1969. 413 pp. £1.90 (38s.). (No. 1762)

Analysis of Surge.
J. Pickford.
Macmillan, 1969. 196 pp. £2.75 (55s.). (No. 1764)

Coastal Hydraulics.
A. M. Muir Wood.
Macmillan, 1969. 175 pp. £2.75 (55s.). (No. 1765)

American Welding Society Welding Handhook.
6th Edition, Part 2:
Welding Processes: Gas, Arc and Resistance.
Edited by A. L. Phillips.
Macmillan, 1969. 600 pp. £6.00 (120s.). (No. 1768)

Workshop Theory and Exercises.
J. Kirkham and H. Harris.
Blackie, 1969. 165 pp. £1.25 (25s.). (No. 1775).

Machine Tool Dynamics.
D. B. Welbourn and J. D. Smith.
Cambridge University Press., 1970. 144 pp. £2.00 (40s.). (No. 1779).

Instrumentation: Pressure and Liquid Level.
F. E. Doyle.
Blackie, 1970. 89 pp. £0.85 (17s.). (No. 1781).

ABC's of Thermistors.
R. P. Turner.
Foulsham Sams, 1970. 96 pp. £1.10 (22s.). (No. 1786)

Applied Mathematics: SI Units.
E. D. Hodge and B. G. J. Wood.
Blackie, 1970. 302 pp. £1.50 (30s.). (No. 1787).

Heat (3rd Edition): SI Units.
M. Nelkon.
Blackie, 1970. 232 pp. £1.25 (25s.). (No. 1788).

Applications of Mathematical Programming Techniques.
Edited by E. L. M. Beale.
English Universities Press Ltd., 1970. 451 pp. £5.25 (105s.). (No. 1789)

Operational Research in Maintenance.
Edited by A. K. S. Jardine.
Manchester University Press, 1970. 229 pp. £4.80 (96s.). (No. 1790)

Instrumentation: Temperature.
F. E. Doyle and G. T. Byron.
Blackie, 1970. 53 pp. £0.75 (15s.). (No. 1791)

Technical Drawing (in Metric Units).
W. Abbott.
Blackie, 1970. 208 pp. £1.50 (30s.). (No. 1792)

In-water Photography.
L. E. Mertens.
Wiley-Interscience, 1970. 391 pp. £9.50 (190s.). (No. 1793)

Manpower Research
Edited by N. A. B. Wilson.
English Universities Press Ltd., 1969. 463 pp. £5.00 (100s.). (No. 1794)

Brittle Fracture in Steel Structures.
Edited by G. M. Boyd.
Butterworths, 1970. 122 pp. £4.25 (85s.). (No. 1795)

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